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JOURNAL

OF THE

Elisha Mitchell Scientific Society

Volume 51 December, 1935 No. 2

PROCEEDINGS OF THE THIRTY-FOURTH ANNUAL MEETING OF THE NORTH CAROLINA ACADEMY OF SCIENCE

THE WOMAN'S COLLEGE OF THE UNIVERSITY OF NORTH CAROLINA, GREENSBORO, N. C., MAY 3 AND 4, 1935

The thirty-fourth annual meeting of the North Carolina Academy of Science was held at the Woman's College of the University of North Carolina, May 3 and 4, 1935. The meeting was called to order at 9:30 A.M. on May 3, by the president, Dr. H. R. Totten. The reading of papers was begun promptly and continued until 12:30 P.M. when the president announced the appointment of the following committees:

Auditing: A. D. Shaftesbury, G. R. MacCarthy, F. W. Sherwood.

Nominating: H. B. Arbuckle, Bert Cunningham, B. W. Wells.

Resolutions: W. L. Porter, M. L. Braun, J. B. Derieux.

The Academy then took a recess for luncheon.

The reading of papers was resumed at 2:15 P.M. and continued until 4:30 P.M. when the Academy held its annual business meeting.

The minutes of the previous meeting were approved as published in the *Journal of the Elisha Mitchell Scientific Society*.

Reports were then called for from the various committees.

The executive committee, consisting of H. R. Totten, the president of the Academy, P. M. Ginnings, vice-president, H. L. Blomquist, secretary and treasurer, Charles M. Heck, E. T. Browne, and W. E. Speas reported as follows:

"The executive committee met in Greensboro on May 2 and again on May 3 with all members present except Charles M. Heck who was unable to attend.

"The committee appointed E. T. Browne to act as temporary assistant to the secretary during the meeting.

"The committee acted favorably on the request by Dr. E. K. Plyler that his paper be transferred on the program from the general section to the physics section.

"Favorable action was also taken in response to the request by Dr. W. F. Prouty and Dr. G. R. MacCarthy that the places of their respective papers on the program be exchanged.

"The titles which arrived too late to appear on the printed program were accepted and added to the program, one before the general section and three before the physics section.

"The committee reported as elected to membership since the last annual meeting the following:

Bartlett, Grady, Dept. of Physics, State College, Raleigh, N. C.
Beck, Clifford, Boyden High School, Salisbury, N. C.
Billings, W. Dwight, Dept. of Botany, Duke U., Durham, N. C.
Bloxam, Percy, Milford Mills, Salisbury, N. C.
Boggess, W. R., Dept. of Botany, Duke U., Durham, N. C.
Brimley, Ralph F. W., Reynolds High School, Winston-Salem, N. C.
Carlsson, Victoria, Dept. of Hygiene, W.C. of U.N.C., Greensboro, N. C.
Chamberlain, B. R., 1824 East 7th St., Charlotte, N. C.
Coldwell, Inez, Dept. of Biology, W.C. of U.N.C., Greensboro, N. C.
Correll, Don, Dept. of Botany, Duke U., Durham, N.C.
Dearborn, D. C., Dept. of Math., Duke U., Durham, N. C.
Deatrick, E. P., Erosion Exp. Sta., Statesville, N. C.
Duncan, W. H., Dept. of Botany, Duke U., Durham, N. C.
Edwards, Margaret, Dept. of Home Economics, W.C. of U.N.C.
Eller, Frank, Dept. of Biology, Catawba College, Salisbury, N. C.
Emory, S. T., Dept. of Geology, U.N.C., Chapel Hill, N. C.
Evinger, E. L., Soil Erosion Nursery, Chapel Hill, N. C.
Hard, W. L., Dept. of Zoology, Duke U., Durham, N. C.
Harkema, Reinard, Dept. of Zoology, Duke U., Durham, N. C.
Howe, M. Dorisse, Dept. of Biology, Queen's Chicora C., Charlotte, N. C.
Huddle, J. W., Dept. of Geology, U.N.C., Chapel Hill, N. C.
Johnson, W. R., Dept. of Geology, U.N.C., Chapel Hill, N. C.
McCampbell, J. C., Dept. of Geology, U.N.C., Chapel Hill, N. C.
Merwin, Marion, Dept. of Biology, Catawba College, Salisbury, N. C.
Middlekauff, Hugh, Dept. of Biology, Catawba College, Salisbury, N. C.
Miller, James Kyle, 2100 Burlington Ave., St. Petersburg, Fla.
Morgan, Karl Z., Dept. of Physics, Lenoir-Rhyne College, Hickory, N. C.
Poole, Frazer, Dept. of Biology, Catawba College, Salisbury, N. C.
Raynal, Chas. E., Statesville, N. C.
Reed, John, Dept. of Botany, Duke U., Durham, N. C.
Reed, Mildred Stites, Dept. of Botany, Duke U., Durham, N. C.
Ruark, Arthur E., Dept. of Physics, U.N.C., Chapel Hill, N. C.

Ryburn, W. O., Jr., Dept. of Biology, Catawba College, Salisbury, N. C.
Spangler, Helen, Dept. of Botany, Duke U., Durham, N. C.
Summerell, Frances, Dept. of Biology, W.C. of U.N.C., Greensboro, N. C.
Van Note, Wm. G., Chemical Engineering, State College, Raleigh, N. C.
Webb, T. N., Dept. of Botany, Duke U., Durham, N. C.
Williams, Myra A., Peace Junior College, Raleigh, N. C.

Other nominees were considered by the committee, and the secretary was authorized to consider these as elected upon payment of the initiation fee.

The following were reinstated to membership:

Bookhout, C. G., Elon College, N. C.
Bullard, Lena, Greensboro High School, Greensboro, N. C.
Campbell, Eva, Guilford College, N. C.
Crittenden, Charles, W.C. of U.N.C., Greensboro, N. C.
Dodson, C. F., Campbell College, Buies Creek, N. C.
Douglas, J. M., Davidson College, Davidson, N. C.
Edmister, F. H., Chapel Hill, N. C.
Fritz, R. L., Lenoir-Rhyne College, Hickory, N. C.
Harris, Mildred, W.C. of U.N.C., Greensboro, N. C.
Klenner, Frederick R., Duke Hospital, Durham, N. C.
Latham, Dennis, Dept. of Botany, State College, Raleigh, N. C.
Ljung, Harvey A., Guilford College, N. C.
Lutz, J. F., Dept. of Soils, State College, Raleigh, N. C.
Lyon, Scott Cary, Davidson College, Davidson, N. C.
Petty, Mary, W.C. of U.N.C., Greensboro, N. C.
Purdom, Emil G., Guilford College, N. C.
Saylor, John M., Duke U., Durham, N. C.
Williams, Maude, W.C. of U.N.C., Greensboro, N. C.
Yoder, M. C., Lenoir-Rhyne College, Hickory, N. C.

"The committee also reported the following losses during the year:

Lost by death:
Dr. Collier Cobb, Professor of Geology and former head of the department of Geology at U.N.C., Chapel Hill, N. C.

Lost by resignation because of removal from state:
McCay, M. S.
Sims, I. H.

Lost by resignation:
Graham, Maria D.

Dropped from the roll because of non-payment of dues:
Twenty-one former members.

The Treasurer's report was as follows:

Financial Statement of the N.C.S.A. May 3, 1934 to May 1, 1935

Receipts		Expenditures	
Balance on hand May 4, 1934	$515.86	Stationery and Printing	$56.21
Dues for 1934	152.00	Same	72.28
Initiation fees for 1934	16.00	Addressographing	4.67
Dues for 1935	210.00	Postage	1.97
Initiation fees for 1935	46.00	Express on H. S. Essays and Stationery	.93
Interest on savings	14.69	Long Distance Calls	1.70
Allotment from A.A.A.S.	1.00	Books for H. S. Essay Prize (1934)	15.39
N.C. Section Am. Chem. Soc. (Share toward programs)	5.00	Expenses for presenting prize	5.00
	$960.55	Minute book for physics sec.	1.20
		Clerical Assistance	53.20
		Dues refund to Sec	2.00
		Sec.-Treas. Commission	42.40
		Journal of E.M.S.S. (Partial payment, 1934)	150.00
		Tax on checks	.38
		Charges on bank balance	1.50
		File and receipt books	1.70
		Total	$410.53
		To balance	550.02
			$960.55

Comparison

	1934		1935	
Savings Account	$511.92		$476.59	
Checking Account	3.54		73.43	
Cash on hand	.40		.00	
	$515.86		$550.02	
Outstanding obligation	150.00		135.00	(At present time)
	$365.86		$415.02	
To balance (net loss)	100.70	(gain)	49.16	
	$466.56		$365.86	

The above report was made as of May 1, 1935.
Submitted by H. L. Blomquist, Secretary-Treasurer.
Audited May 3, 1935 by
Archie D. Shaftesbury,
Gerald R. MacCarthy,
F. W. Sherwood.

"The committee accepted the invitation of the faculty and administration of Duke University to hold the thirty-fifth meeting in Durham.

"The executive committee made the following recommendations to the Academy:

1. That all bills presented in the Treasurer's Report be authorized and paid and that the Report be printed when audited.

2. That Bert Cunningham be appointed to select the books to be given to the winner of the High School Science Essay Prize, and that he be authorized to draw upon the Treasury for as much as $25.00 for these books; and that the Secretary be authorized to appoint a representative of the Academy to award the prize and draw upon the Treasury for the payment of his expenses.

3. That the Academy elect to life membership Dr. E. W. Gudger of the American Museum of Natural History, New York City, and R. N. Wilson, Professor of Chemistry, Duke University.

Dr. Gudger joined the Academy in 1906, acted as its secretary and treasurer from 1908 to 1918, and as its president in 1919. Although he has been out of the state for many years, he has retained his active membership with a spirit of loyalty to the Academy and the state.

Professor R. N. Wilson joined the Academy in 1902, the year of the founding of the Academy, and acted as its vice-president in 1920.

4. That the library of the University of North Carolina be officially recognized as the depository of the Academy for exchanges and permanent records.

5. That the secretary be instructed to publish the revised Constitution and By-laws, list of past officers, and roll of present members with the 1935 Proceedings in the Journal of the Elisha Mitchell Scientific Society, and that 250 reprints be made; also that 50 reprints be made of the 1935 Proceedings for the purpose of exchange with other state academies, provided the total cost of reprints does not exceed $40.00.

The auditing committee reported that they had examined the accounts of the treasurer for the period of May 4, 1934, to May 1, 1935, and found them correct.

The reports of the treasurer and auditing committee were accepted.

The committee on high school science, consisting of Bert Cunningham, chairman, H. B. Arbuckle, Lena Bullard, C. M. Heck, C. E. Preston, and R. N. Wilson, reported as follows:

"The usual activities have been carried on during the year. These consist of the assistance in the Divisional Meetings of the North Carolina Educational Association, and the conducting of the annual essay contest.

"Members of the Academy attended four of the six divisional meetings

and appeared on the programs, and also attended the state meeting where they virtually monopolised the program. While it is desirable that members of the Academy attend these meetings and occasionally appear on the programs, it appears to the committee that it would be better if more people engaged in high school work would appear on the program and discuss more fully their own problems. It is also desirable that a greater variety of college and university professors appear on these programs, and the Committee urges that invitations to appear on various programs be accepted, if received.

"The annual essay contest brought forth forty papers from twenty-seven competing schools. This number represents only a small part of the essays which were written for the contest since no school is permitted to submit more than three papers.

"The judges selected were: Chairman, E. H. Hall, Woman's College of the University of North Carolina, P. J. Kramer of Duke University, and J. N. Couch of the University of North Carolina. This committee selected Thelma Bardwell of Montreat College High School, as winner of the prize for her essay entitled 'Mental Hygiene.'

"The committee feels that a continuation of the contest is desirable and recommends that the subject for next year be restricted to the fields of Physics and Chemistry."

The report of the committee on high school science was accepted and its recommendations adopted.

The legislative committee, made up of Z. P. Metcalf, chairman, W. L. Poteat, and C. S. Brimley, did not have a report at this time.

The committee on the standardization of college science courses, consisting of Bert Cunningham, chairman, P. M. Ginnings, H. R. Totten, J. B. Bullitt, and K. H. Fussler, made a supplementary report as follows:

"Section B of this report was laid on the table at the last meeting of the Academy in order that members of the Academy might have more time for deliberate consideration of the provision of an Appraisal Committee, and that the Committee might have more time to get the reaction of administrative officers who would of necessity have to coöperate if the plan is to be a success.

"The Committee has attempted to get the viewpoint of administrative officers by submitting Section B to them and asking for frank comments concerning the plan. A sufficiently large proportion of them have replied, and the replies have come from various types of institutions so that a summary may be made of their views. In a word, the great

majority believe that this would be a good project if it is properly protected and if the smaller institutions are protected.

"With the additional information at hand, your committee is ready to recommend the adoption of Section B of its earlier report."

This report was accepted and the committee discharged.

The following memorial report honoring the late Dr. Collier Cobb, was presented by the chairman of a special committee:

DR. COLLIER COBB

The death of Professor Collier Cobb on November 28th, 1934, at Chapel Hill has taken from the North Carolina Academy of Science one of its most loyal supporters.

Professor Cobb was born at Mt. Auburn Plantation, Wayne County, North Carolina, on March 21, 1862. His journalistic talents developed early. In childhood he wrote, printed, and distributed a small newspaper; and as a Harvard student he instituted what is believed to be the first syndicated news service.

Following two years at Wake Forest and one at the University of North Carolina, Professor Cobb taught for five years in the secondary schools of the state before going to Harvard where he received the A. B. and M.A. degrees. During his last two years at Harvard he was instructor in the Massachusetts Institute of Technology.

In 1892 Professor Cobb came to the University of North Carolina as Assistant Professor. The following year he was made Professor and first head of the Department of Geology.

Professor Cobb was closely associated with the activities of the Academy of Science from the time of its first annual meeting in 1902. He responded to the address of welcome at this first meeting, was the sixth president of the Academy, and during his 32-year membership seldom failed to present one or more papers at each meeting.

Professor Cobb possessed an extremely active mind and an untiring energy. His interest in world affairs and in travel made him nearly as well known abroad as in the United States. His interest in humanity was genuine and far reaching. This interest, coupled with a keen knowledge of people and customs, together with his deep sense of humor and his gift of interesting conversation, led to many contacts and friendships with all classes of people in his world travels. His striking personality, keen intellect, and remarkable memory, expressed in a wealth of rare anecdotes, made him the central figure in any group. Always an interesting lecturer and public speaker, he was much in

demand for this purpose. His teaching and personality so impressed his students that many of them went on to successful careers in geology, and in later years the sons and daughters of former students sought out Professor Cobb's classes as a high spot of interest in their college experiences.

Although Professor Cobb's publications cover a wide field of thought, his major interests were those of human geography and shoreline processes and development, as shown by the following titles: *Where the Wind Does the Work, Lands and Dunes of Gascony, Loess Deposits of China, Early English Survivals on Hatteras Island.* His Pocket Dictionary of Common Rocks and Rock Minerals was much used throughout the country, and his map of North Carolina ran through six editions.

Professor Cobb lived to realize one of his greatest ambitions in the firm establishment of an active department of geology at the University of North Carolina before he resigned as head of the department in 1932 and began the preparation of a book of reminiscences. It is most regrettable that he did not live to finish this work which would have held so much of value and interest for many people both here and abroad.

In the best sense Professor Cobb was a Christian. He was a loyal member of the Baptist Church, supporting its activities with his counsel and his purse. He gave liberally to the cause of Christian missions, regardless of denominational affiliation, and could be counted on to support any deserving cause. Long a deacon of his church and a Sunday School worker, he was one of the most influential Baptist laymen in the state, always exerting his influence for liberalism in religion.

Professor Cobb was always prompt to recognize and perform his duty. He was a loyal citizen, a good neighbor, interested in the activities of the University, the town and the state, a man of high ideals, optimistic, and eternally young.

A gentleman of the old school, yet always forward looking, Professor Cobb will be remembered as one of the most vivid personalities of our group. His death removes one of the best known and best beloved citizens of the state. It is given unto few to have touched and influenced as many lives as did Professor Cobb in his long and useful career.

WM. F. PROUTY,
W. L. POTEAT,
J. L. STUCKEY,
Committee.

The report was accepted by a standing vote and the secretary was instructed to place the report in the minutes and to send a copy to the family.

The general resolutions committee reported as follows:

"The Academy hereby expresses its appreciation of the hospitality of the Woman's College of the University of North Carolina.

"In particular we desire to mention the manner in which the committee on arrangements has anticipated every need and comfort of the Academy.

"We desire also to recognize the cordiality and coöperation of the Chamber of Commerce of the city of Greensboro. To all of these agencies we are largely indebted for such a pleasant and profitable meeting."

M. L. BRAUN,
J. B. DERIEUX,
W. L. PORTER,
Committee.

The above resolutions were adopted.

A recommendation was made and passed that the committee on public school curriculum be revised.

C. F. Korstian, the representative of the Academy to the A.A.A.S., reported as follows:

Two matters should be brought before the Academy:

1. The A.A.A.S. is attempting to stimulate the organization of junior academies in the various states through the state academies. In this connection it might be well to point out the possible desirability of stimulating the organization of local science clubs in a number of our larger high schools and in some of the larger or more aggressive communities. This seems preferable to sponsoring the so-called junior academies.

2. Concerning the organization of local branches of the A.A.A.S. it is suggested that our Academy pass a resolution that whenever the organization of local branches of the A.A.A.S. is contemplated, we would urge upon the officials of the A.A.A.S. that the local academy be fully consulted before such steps are taken.

The report was accepted.

A motion was made and carried that the Academy go on record as not favoring junior academies, but as being willing to encourage and offer its services to help high school science clubs.

A second motion was made, that the secretary communicate with the Permanent Secretary of the A.A.A.S. and request that the state academies be consulted before establishing local branches of the A.A.A.S. This motion was passed.

A third motion was made stating that the Academy is not in favor of the establishment of a Southeastern Branch of the A.A.A.S.

After some discussion, this motion was also passed.

Following a discussion concerning the destruction of non-timber trees and shrubs in the state by the activities of the CCC organizations, a committee, consisting of Chas. E. Raynal, B. W. Wells, and J. P. Givler, was appointed to draw up a resolution, which follows:

Whereas it has been brought to the attention of the North Carolina Academy of Science that in certain places an apparently ruthless and unnecessary destruction of thousands of trees and shrubs both of aesthetic and commercial value, has resulted from the activities of the CCC organizations, the Academy presents the following resolution for consideration:

Be it resolved that the North Carolina Academy of Science is greatly disturbed over the excessive destruction in certain places of the valuable trees and shrubs in our National and State Forests.

As citizens of the United States and interested in the conservation of our timber trees and native shrubs, we call attention to what we consider a short-sighted and dangerous policy in the use of the CCC men in our forest areas. We petition:

1. That a more exact determination be made of the meaning of the terms "timber" vs. "weed" trees. We call attention to the fact that holly and dogwood, for example, have a commercial value, greatly in excessive of the ordinary timber trees and should be protected from excessive or wanton destruction.

2. That when non-timber trees and shrubs do not interfere with more important growth, they be preserved.

3. That the policy of setting aside special areas where these plants will be left entirely undisturbed, be carried out to a larger degree, resulting in a reasonable increase in such areas in every State and National forest.

It is suggested that this resolution be placed in the hands of all high administrative officers concerned, including the President, the Director of the Forest Service, the Director of the CCC camps, the Governor of North Carolina, the Director of the Erosion Control Service, and the North Carolina State Forester.

The nominating committee submitted the following nominations:

President—W. L. Porter, Davidson College.

Vice-president—F. W. Sherwood, State College.

New member of the Executive Committee (for three years)—H. R. Totten, The University of North Carolina.

The nominations were accepted and the secretary was instructed to cast the ballot of the Academy for the nominees.

The president then announced the appointment of the following committees:

Legislative Committee: Z. P. Metcalf, chairman, W. L. Poteat, Wm. F. Prouty.

Committee on High School Science: Bert Cunningham, chairman, H. B. Arbuckle, C. E. Preston, Mrs. B. W. Wells, Lena Bullard, Nancy Eliason.

Committee on Public School Curriculum: C. E. Preston, chairman, Mrs. B. W. Wells, Lena Bullard.

Committee on Zoological Nomenclature: Z. P. Metcalf, chairman, C. E. Stiles, R. E. Coker.

Conservation Committee: Chas. E. Raynal, chairman, B. W. Wells, J. P. Givler, T. G. Harbison, C. F. Korstian, W. C. Coker, C. S. Holmes.

Elective Appraisal Committee: General Section, E. H. Hall, R. E. Coker, Mary Conrad Cleaver. Physics Section, C. W. Edwards, Karl Fussler, E. G. Purdom. Chemistry Section, R. N. Wilson, J. T. Dobbins, P. M. Ginnings.

The business meeting then adjourned.

At 6:45 P.M. the members of the Academy were entertained at a complimentary dinner given by the Woman's College in South Dining Hall.

The Academy reconvened at 8:30 P.M. in the auditorium of the Student Building with P. M. Ginnings, the vice-president presiding. Dean Geneva Drinkwater welcomed the Academy to the Woman's College and to Greensboro. President H. R. Totten delivered his presidential address entitled "The Caprifoliaceae or Honeysuckle Family in the Southeastern States." The address was well illustrated by herbarium specimens.

At 9:30 P.M. the Academy members and visitors met for an enjoyable social hour in Society Hall.

On Saturday morning the Academy met in sections. President Totten presided over the general section; E. R. C. Miles over the

mathematics section with W. N. Mebane, Jr. as secretary; Calvin N. Warfield over the physics section with J. S. Meares as secretary; and J. M. Saylor over the chemistry section with W. C. Vosburgh as secretary.

The following officers were elected by the respective sections:

Mathematics Section—Chairman, W. N. Mebane, Jr., Davidson College; Secretary, V. A. Hoyle, The University of North Carolina.

Physics Section—Chairman, C. C. Hatley, Duke University; Secretary, J. S. Meares, North Carolina State College.

North Carolina Section of the American Chemical Society—Chairman, R. W. Bost, The University of North Carolina; Vice-chairman, A. M. White, The University of North Carolina; Secretary-treasurer, W. C. Vosburgh, Duke University; Councilor, L. A. Bigelow, Duke University; Executive committee, the officers, J. S. Black, Wake Forest College, H. D. Crockford, The University of North Carolina, F. W. Sherwood, North Carolina State College.

The following papers were presented. Those marked with * appear in full in this issue. Those marked x are abstracted with the Proceedings. Those marked † were read by title.

GENERAL SECTION

x*Further Observations on the Effect of Increased Atmospheric Pressure on the Incubating Hen Egg* (Lantern). BERT CUNNINGHAM, Duke.

x*Economic Uses for Cellulose Materials of the Coastal Plain.* E. E. RANDOLPH, State.

x*Resistance of the Air to Golf Balls at Different Velocities.* J. B. DERIEUX, State.

x*Effect of Nitrogen Fertilizers on Strawberry Production* (Lantern). R. A. LINEBERRY, U. S. D. A., and H. B. MANN, State.

Menhaden Fish Oil as a Source of Vitamin D for Growing Chicks (Lantern). J. O. HALVERSON, R. S. DEARSTYNE, F. H. SMITH and F. W. SHERWOOD, State.

The Structure of Plant Cell Walls (Lantern). DONALD B. ANDERSON, State.

x*Further Observations Concerning the Origin of the "Carolina Bays"* (Opaque Lantern). WM. F. PROUTY, U. N. C.

x*Meteors and the Carolina Bays* (Opaque Lantern). GERALD MACCARTHY, U. N. C.

Observations on Downy Mildew of Tobacco. FREDERICK A. WOLF, Duke.

x*After-Effects in the Stretching of Rubber* (Lantern). MILTON L. BRAUN, Catawba.

Fertility of Diploid Males and Triploid Females in the Wasp Habrobracon (Lantern). C. H. BOSTIAN, State.

x*The Effect of Length of Day and Soil Temperature upon Nodulation of Soybeans* (Lantern). C. B. CLEVENGER, State.

A Survey of the Liverworts of North Carolina. H. L. BLOMQUIST, Duke.

x*An Adventure in Natural Science Education.* B. W. WELLS, State.

**A Study of the Cave Spider, Nesticus pallidus, to Determine Whether It Breeds Seasonally or otherwise.* J. D. IVES, Carson and Newman College.

The Effect of Various Cations on Certain Physico-Chemical Properties of Soil Colloids (Lantern). J. F. LUTZ, State.

A Study of North Carolina Species of Cyperus and their Distribution. MILDRED STITES REED, Duke.

Two New Sac Fungi. W. C. COKER, U. N. C.

Question Concerning Conservation of the Non-Timber Trees and Shrubs in the National Forests of North Carolina. T. G. Harbison, U. N. C.

Oil Films on Water: their Peculiar Motions and Physical Properties. CHAS. M. HECK, State.

x*Some Aspects of the Chemical Engineering Laboratory.* C. S. GROVE, State.

x*Behavior of Chrome-Nickel Alloys in Phosphoric Acid Solutions* (Opaque Lantern). W. C. WALLIN and C. S. GROVE, State.

Origin, Development and Function of the Oenocytes of the Honeybee, Apis mellifica Linn. A. D. SHAFTESBURY, W. C. of U. N. C.

x*Contact as a Stimulus to Localized Growth* (Lantern). W. C. GEORGE, U. N. C.

The Effect upon a Cecil Clay Type of Soil from a Continuous Application of Mineral Plant Food Elements (Charts). G. M. GARREN and E. E. RANDOLPH, State.

x*Work of the Soil Erosion Experiment Station* (Lantern). E. P. DEATRICK, Statesville.

Time Elements in Transmission of Radio (Lantern). G. W. BARTLETT and C. M. HECK, State.

Recent Advances in the Knowledge of the Atomic Nucleus. C. W. EDWARDS, Duke.

Parasites of North Carolina Rodents. REINARD HARKEMA, Duke.

x*Systematic Zoology* (Lantern). Z. P. METCALF, State.

†*New Parasites from North Carolina Frogs* (Lantern). B. B. BRANDT, Duke.

†*A New Achlya from the Soil* (Lantern). DENNIS H. LATHAM, State and U. N. C.

†x*The Silurian of Eastern Tennessee* (Opaque Lantern) WM. F. PROUTY, U. N. C.

x*Regeneration of Functional Testes in Birds* (Lantern). BERT CUNNINGHAM, Duke.

x*An Attempt to Locate the Boundaries of the Durham Triassic Basin with a Magnetometer.* W. R. JOHNSON, JR., and H. W. STRALEY, U. N. C.

MATHEMATICS SECTION

x*Solutions of a Simple Type of Stieltjes-Integro-Differential Equation.* F. G. DRESSEL, Duke.

x*Complete Sets of Inequalities on Arithmetical Invariants of Pfaffian Systems.* D. C. DEARBORN, Duke.

x*Associated Algebraic and Partial Differential Equations.* JOSEPH A. GREENWOOD, Duke.

On Monge's Differential Equation. J. W. LASLEY, JR., U. N. C.

x*On the Matric Equations* $P(X) = A$ *and* $P(A,X) = 0$. EDWARD T. BROWNE, U. N. C.

PHYSICS SECTION

x*The Isothermal Elongation of a Stretched Rubber Band* (Lantern). MILTON L. BRAUN, Catawba.

**Change of Resiliency with Velocity of Impact* (Opaque Projection). J. B. DERIEUX, State.

Some Comments on Recent Studies of Cosmic Ray Showers. W. M. NIELSEN, Duke.

Ionization of Neon and Argon by Singly Charged Magnesium Ions (Lantern). J. C. MOUZON and N. H. SMITH, Duke.

A Discussion of the Classical Aspect of the Ionization of Gases by Slow Positive Ions. J. C. MOUZON, Duke.

The Variation with Temperature and Magnetization of the Thermoelectric Behavior of Ferromagnetic Substances. F. W. CONSTANT and F. E. LOWANCE, Duke.

A Preliminary Report of the Absorption Spectra of CO_2 *and HCl.* A. P. CLEAVES, Duke.

x*The Infrared Absorption Spectra of Acetic Acid and Acetic Anhydride.* E. K. PLYLER and E. S. BARR, U. N. C.

x*On the Half Lives of Potassium, Rubidium, Neodymium and Samarium.* ARTHUR E. RUARK and KARL H. FUSSLER, U. N. C.

Some Theorems on Statistical Fluctuations in Radioactive Phenomena. ARTHUR E. RUARK, U. N. C.

Evidence for Shell Structure in the Atomic Nucleus. KARL H. FUSSLER, U. N. C.

EXHIBITS

Granites of Rowan County. EMMETT E. CRUSE, JR., Catawba.
Soil Erosion. E. P. DEATRICK, Statesville.

NORTH CAROLINA SECTION OF THE AMERICAN CHEMICAL SOCIETY

The Quantitative Determination of Cobalt in the Presence of Iron. J. T. DOBBINS, U. N. C.

The Relative Ease of Removal of Hydrogen Bromide from Certain Bromamides by means of Alkali. C. R. HAUSER and W. B. RENFROW, Duke.

x*Gassing-Voltage-Gravity-Temperature Relationships in Lead-Acid Storage Cells.* H. D. CROCKFORD and W. R. SINK, U. N. C.

x*The Isolation of a New Cyclic Amino Acid.* E. W. MCCHESNEY, U. N. C.

Some Factors Affecting the Solubility of Slightly Soluble Organic Liquids in Water. J. M. SAYLOR, J. C. RINTELEN and P. M. GROSS, Duke.

Business Meeting

The Determination of Sodium and Potassium in Lake Deposits. C. S. BLACK and C. M. PRESLAR, Wake Forest.

Oxidation-Reduction Equilibria in Soils. L. G. WILLIS, State.

The Preparation of Pure Fluorine and its Continuous Reaction with Hexachlorobenzene. LUCIUS A. BIGELOW and WILLIAM T. MILLER, JR., Duke.

Ternary Systems; Water, Allyl Alcohol and Salts at 25°. P. M. GINNINGS and MARY DEES, Greensboro College.

x*A Color Test for the Identification of Mono-, Di- and Trinitro Compounds.* R. W. BOST and FRANK NICHOLSON, U. N. C.

Activity Coefficients for 0.1 to 4 Molal Aqueous Hydrochloric Acid Solutions. W. F. WYATT, JR., Wake Forest.

The following abstracts have been received:

Further Observations on the Effects of Increased Atmospheric Pressure on the Incubating Hen Egg. BERT CUNNINGHAM.

Further experiments indicate that there is an acceleration in the growth rate of chick embryos under pressure. Desiccation of such embryos reveals an increase in weight of organic materials indicating that the growth is real and not due to hydration.

More elaborate studies of the effects of pressure on post-hatching growth, which was earlier suggested, show that while there is neither earlier hatching nor greater hatching weights, the pressure chicks grow more rapidly after hatching.

Although one might expect some marked effect on the sex ratios on the "metabolic theory" of sex, no such effect is apparent in the data, which it must be admitted is neither adequate nor satisfactory for a final decision.

Economic Uses for Cellulose Materials of the Coastal Plain. E. E. RANDOLPH.

The census report indicates that over seven million cords of wood are consumed annually in the United States in pulp making and it is estimated that more than one hundred million cords have been used in making paper and pulp and that of this enormous amount of wood approximately 75 per cent has been Spruce and Balsam. The supply of these types of trees is therefore so greatly diminished that other sources of suitable cellulose raw materials must be discovered to supply the demand. State College Chemical Engineering Department is making a careful study of the timber growth of the Coastal Plain to find the economic values of the different types of trees native to this area.

Many thousands of acres of land are marshy and cannot be successfully drained for agricultural pruposes. The land, however, is extremely fertile, the climate is mild; hence a large variety of trees grow naturally on this swampy land so that the period necessary for a tree to reach maturity is much shorter in this area than it is in northern climates.

It has been found that some of these timbers make excellent fiber which when prepared under proper conditions is suitable for practically all purposes. Other types of trees have limited range as suitable pulp material. Good paper, rayon, cellophane, plastics and varnish have been made from the Cypress and Pine. These studies include also other cellulose raw materials such as peanut hulls, grass, and other cellulose producing raw materials.

The necessity of this study is apparent from the following considerations:

1. The enormous amount of paper and pulp required to supply the needs of the country;
2. The rapidly diminishing supply of trees formerly used and the consequent increase in cost of the present available supply;
3. Indications that suitable pulp can be economically prepared from other kinds of trees and other kinds of other raw materials;

4. The vast areas in this state suitable for rapid timber growth and entirely unsuitable for any other use;
5. The possibility of stimulating industrial activity in an area in which not a great variety of industries exists;
6. The nature of cellulose itself;
7. The nature of other constituents of wood available for pulp.

In these studies it is assumed that cellulose is identical regardless of its source; that the cellulose molecule may not be as complex as is sometimes believed, that the cellulose molecule consists of four $C_6H_{10}O_5$ units symmetrically arranged with reference to each other or of some multiple of these four symmetrical units; that each unit contains three alcohol groups, two secondary and one primary; that cellulose is a relatively inactive body; and that because of its trihydric nature its reactions in the production of conversion products necessarily proceeds in steps, so that if conditions are not rigidly controlled intermediate products are also acted on, resulting in a final product far from uniform.

Various kinds of woods contain different kinds of associated constituents such as lignin, tannin, resins, and gums which are partially removed in the pulping process. The different kinds of timber require different chemical treatment to remove these constituents. Oxidizing agents and alkalies attack some of the cellulose converting it into oxycellulose and even to glucose as an end product, whereas acid treatment unless rigidly controlled may convert some of the cellulose into dextrin, into polyose groups, and finally may proceed to glucose.

It is apparent that if proper conditions can be observed the undesirable associated constituents may be removed to a reasonable degree without seriously attacking the cellulose itself. The extent of this purification process must be determined from the nature of the tree. A number of these trees give favorable results.

Resistance of the Air to Golf Balls. J. B. DERIEUX.

The following data on the resistance of the air to golf balls, were obtained by suspending the balls in a wind tunnel. The manner of suspension was that of a simple pendulum, with the fixed end of the fine thread attached at the origin of a large circular degree scale on cardboard, the cardboard being vertical and parallel with the wind. The angular deflection of the pendular arrangement, when the wind was blowing, was read at the point where the thread crossed the degree scale, with which it was in close contact at all times. The resistance was computed from the right-angled force triangle of the three forces under which the ball was in equilibrium. The equation for it is R =

W x tan θ, where W is the weight of the ball, and θ is the angular deflection. The velocity corresponding was read from tunnel gauge, after calibration by anemometer.

The golf balls used were of the present standard dimensions, 1.62 ounces in weight, and 1.68 inches in diameter, but had been played with some, so that they had an average weight of only 1.60 ounces.

DATA

TUNNEL GAUGE	DEFLECTION TANGENT	VELOCITY OF AIR	WEIGHT OF BALL	RESISTANCE OF AIR
in.		*ft./sec.*	*lbs.*	*lbs.*
1.37	4.54×10^{-2}	24.0	0.100	4.54×10^{-2}
1.75	5.94 "	27.5	0.100	5.94 "
2.00	6.47 "	29.8	0.100	6.47 "
2.38	7.87 "	33.0	0.100	7.87 "
2.69	8.93 "	35.3	0.100	8.93 "
2.94	9.45 "	37.0	0.100	9.45 "
3.31	10.50 "	39.4	0.100	10.50 "
3.62	11.04 "	41.2	0.100	11.04 "
3.88	11.92 "	42.5	0.100	11.92 "
4.28	12.63 "	44.3	0.100	12.63 "
4.50	13.52 "	45.6	0.100	13.52 "

The next part of the problem was to determine the relation of resistance to velocity. Plotting a graph with velocity as abscissa and resistance as ordinate, a smooth curve was obtained, which substantiated the data, but it curved upward, thus showing that the resistance increased faster than the first power of the velocity. A graph with the second power of the velocity curved downward, indicating that the resistance did not increase so rapidly as that. Therefore, it was evident that the increase was between the first and the second power of the velocity. Assuming an exponential form, the equation $R = CV^x$ was set up, where R is the resistance, C a constant, V the velocity, and x the power of the velocity. Two simultaneous equations were derived from this by taking two values of R and the corresponding values of V from the data, and solving for x and for C. It gave 1.63 for x, and 2.62×10^{-5} for C, where R is in pounds, and V in feet per second. Thus the equation of resistance is $R = 2.62 \times 10^{-5} V^{1.63}$. Plotting a graph between velocity to the 1.63 power and resistance, a beautiful straight line was obtained, thus verifying the exponential assumption, and its solution.

The maximum velocity obtainable in the wind tunnel was not very large, but having determined the law of resistance and velocity, as expressed by the preceding equation, it was then possible to compute the

values of the resistance for much higher velocities. It is interesting to note that in a good golf drive, the velocity of the ball as it leaves the club is about 240 feet per second. The resistance of the air to its flight at that stage is 0.2 pound, or twice the weight of the ball, as computed from the formula. Another interesting point is, that for a resistance of the air just equal to the weight of the ball, its velocity would have to be 158 feet per second. Applied to a golf ball dropped from an airplane, this means that while its velocity would increase 32.2 feet per second per second when it was first dropped, this would be gradually decreased by the increase in the air resistance as the ball increased in velocity, and would be 0.0 when the ball attained a velocity of 158 feet per second, the resistance being equal to the weight of the ball, after which it would fall with a constant velocity of 158 feet per second. This would be after a fall of about 2000 feet, as computed from another line of reasoning (see article entitled "Change of Resiliency with Velocity of Impact," in this issue).

This piece of work came as adjunct to another which I was doing, which was on the change of the resiliency of the balls with velocity of impact by the method of fall-and-rebound. In the greater heights of fall and rebound, which I was using, it was necessary that I know the resistance of the air, so as to correct for it in computing the velocity of fall and of rebound.

Effect of Nitrogen Fertilizers on Strawberry Production. R. A. LINEBERRY, and H. B. MANN.

Results of experiments comparing sources of nitrogen in complete fertilizer mixtures, and time of application of nitrogenous fertilizers upon yields, earliness, shipping qualities, and viability of strawberries, are herein reported. On Norfolk sandy loam, fertilizers containing varying proportions of sodium nitrate and cottonseed meal gave the largest yields of strawberries when 80 per cent of the nitrogen was derived from sodium nitrate and 20 per cent from cottonseed meal, but on Coxville sandy loam largest yields were secured each year when the nitrogen was derived equally from sodium nitrate and cottonseed meal. The ammonium sulphate-cottonseed meal mixtures gave largest yields each year on both soil types when the nitrogen was derived equally from the two materials.

Strawberries of better firmness and shipping quality were produced when the fertilizer mixture contained both organic and inorganic nitrogen than when containing inorganic nitrogen alone.

The replacement of slowly available organic nitrogen sources by quickly soluble inorganic nitrogen salts changed the chemical nature of the soil, resulting in low viability of strawberry plants during the summer. This condition was generally associated with high soil acidity and total soluble salts.

Spring applications of either sodium nitrate or ammonium sulphate, in addition to complete fertilizer applied in midsummer and early fall, were injurious if their effect upon earliness and shipping qualities of strawberries is considered. Application of 16 pounds of nitrogen per acre from either sodium nitrate or ammonium sulphate increased the yield slightly over 20 per cent, while larger applications were less effective and were attended by delayed ripening and consequent lower prices for the strawberries. The greatest loss, however, resulted from the poor shipping qualities of the strawberries fertilized with a spring application of nitrogen. Applications of 16 pounds of nitrogen per acre from either sodium nitrate or ammonium sulphate greatly increased the percentage of soft berries after being subjected to shipping conditions, while applications of 32 pounds rendered them almost unfit for shipping purposes, especially for long distances.

Further Observations Concerning the Origin of Carolina Bays. W. F. PROUTY.

About three years ago members of the Department of Geology of the University of North Carolina[1] began the investigation of the nature of elliptical bays and lake basins in the Coastal Plain area of the Carolinas.

As a result of that study a paper was recently published[2] in the *Journal of Geology* favoring the meteoric theory of the origin of these elliptical bays and lake basins. In this article it was shown that there is a magnetic high to be found in association with most of the elliptical depressions and that in most cases the center of this high is a little to the east of south of the southeast end of the elliptical depression and removed from the southeast end a distance about equal to the short axis of the ellipse.

Since the publication of the above article, further field investigation[3] has yielded additional evidence supporting the meteoric theory of the origin of these elliptical depressions. In the previous article it was pro-

[1] W. F. Prouty, G. R. MacCarthy, and J. A. Alexander.

[2] Carolina Bays and Elliptical Lake Basins, Jour. Geol. **43**, No. 2: pp. 200–207, 1935.

[3] W. F. Prouty, G. R. MacCarthy, and H. W. Straley.

posed to make a test case of Dial Bay, and its two associated smaller bays, located near Turbeville, South Carolina. From the theory proposed, there should be found a high magnetic area a little to the east of south from the southeast end of Dial Bay and at a distance about equal to the short axis of the Dial Bay ellipse. The single high magnetic area which had previously been located was assigned by the theory to the eastern of the three bays, and it was held that the high from Dial Bay should be located to the east of south from the southeast end of that bay. Field investigation shows a high area, made up of three minor highs, which fulfills this prediction. It would appear that these minor highs show the presence of three buried portions of the Dial Bay meteor. A small high area to the west of the three high magnetic areas associated with Dial Bay is, in turn, apparently connected with the small bay on the southwest flank of Dial Bay.

Additional magnetometer investigation was made in the area to the northwest and north of White Lake, Bladen County, N. C. The investigation proved this unusually high magnetic area to be eccentrically elliptical, with the magnetic lines of force more closely spaced toward the north. The size of this high and its location conform in general to the theory of a buried magnetic body associated with the origin of the huge bay which is located a little to the west of north of the magnetic high and at a distance equal to the short axis of the bay from the southeast end of the bay.

Meteors and the Carolina Bays. GERALD R. MACCARTHY.

Over 90 per cent of the bays so far investigated show a magnetic high in the proper location to be caused by a meteorite such as would produce the bay with which the high is associated.

Theoretical considerations, substantiated by experiments using high-power bullets, indicate that the bays themselves are the result of the explosive air-blast accompanying the meteorites, and are not simply "punch holes."

From this it follows that the formations lying beneath the bays must be undisturbed except for the much smaller "bullet holes" produced by the meteorites themselves, and since the bays have been filled with sand and swamp-muck the discovery of such holes could be made only by accident.

A comparison of the "bay country" with the area in Siberia affected by the great meteorite fall of 1908 shows that the effects produced in the two regions differ in magnitude rather than in kind.

After-Effects in the Stretching of Rubber. MILTON L. BRAUN.

Twelve similar rubber bands were suspended from the ceiling of a glass door apparatus cabinet last August. Each of three of the bands was slowly given a gravity load of 350 g, another three 550 g, others 750 and 1000 g. Measurements of the lengths of the bands were made at the moment of release of the load, at numerous intervals during the first day, and then daily to date (240 days) or to the breaking of the band. Although the bands were subject to room temperature fluctuations only those observation taken at 27°C were used in determining the relationship between elongation and time. For the first twenty to forty days all bands seemed to lengthen at a positive fractional power rate. The rates according to decreasing magnitude being those for the 550, 750, 1000, and 350 g loads, respectively. Curves for bands having the three highest loads were found to approximate a linear relationship between length and time from about the fortieth day to the breaking point of the band. However, in the case of the highest load there is a very slight upward trend after about 180 days. Curves for the bands with the lowest load were found to pass through a very gradual inflection in the neighborhood of forty days into an ascending power form which continued until the bands finally broke. The bands did not break with a gradual tear but with a sudden snap.

The Effect of Length of Day and Soil Temperature upon Nodulation of Soybeans. C. B. CLEVENGER.

In greenhouse work involving the question of nodulation on soybeans, it was found that the same results in nodulation were not obtained at different seasons of the year, although the soils in which the soybean plants were grown had received similar fertilizer treatments. This suggested that some uncontrolled factor as length of day or temperature was operating.

An experiment was set up to test out these two factors. Soybeans were grown in soil in gallon pots placed in two water tanks. One tank had a temperature range of 20–25°C, and the other was kept at 35°C using a thermostat. Plants at both temperatures were then subjected to both short and long day conditions. The experiment was made during October. For the short day plants the period of light was approximately eight hours, and for the long day plants the period of illumination was extended by the use of artificial light to 10 P.M. All pots were inoculated with soybean organisms.

The results of the experiment are as follows:

(1) The size of the plants varied with the day length for each of the fertilizer treatments, but was not affected by soil temperature.
(2) The root systems of the plants varied inversely with the soil temperature and directly with length of day.
(3) The number of nodules on the roots of the plants of each pot were about the same irrespective of the temperatures and length of day.
(4) The size and dry weights of the nodules were greater on the roots of the plants grown at the lower temperature whether under long or short day.

The soil used, a Coxville sandy loam, was selected at random and for no specific soil property. It is probable, therefore, that the temperature effect upon the size of the nodules is a specific one. This same effect was observed in work at Wisconsin. Recent work by Hopkins of Chicago shows length of day to be a factor in nodule development, which is not confirmed by this experiment.

An Adventure in Natural Science Education. B. W. WELLS.

Report on a 3 months summer course given to freshman and sophomores in 1933 and 1934 at the Columbia University mountain school, known as New College Community, under the direction of Dr. Thomas Alexander of Teachers College. The course emphasized plant science but was unique in that the course throughout was given an ecological complexion. The first three weeks were given to field studies constituting an introduction to the problems of adaptation as these appear in the connection with community distribution. From the very beginning the elementary student was made as equally conscious of habitat as he was of organism. The brief and necessarily superficial ecological introduction was followed by the usual survey of plant structure and functions, but in addition habitat factor measurements were made in the field to supplement the laboratory studies with the microscope and physiological demonstrations. Accompanying the study of the leaf, for instance, photometer measurements were made of a large number of habitats and a number of atmometer readings made at contrasting stations. This carry-over into field situations of functional concepts (something seldom done in the regular college courses in biology) proved most valuable. One full day each week throughout the summer was devoted to field observations during which time all of the major successions were worked out. The course closed with the introduction of a few major animal relations and finally a brief summary of the rôle of the plant communities (including the crops) as the plant life of the region was

related to human life and industries (Canton paper mill, sawmills, etc.) of the area.

The interest aroused through the ecological emphasis in this course in elementary biology, was sufficient to warrant the suggestion that our local institutions of higher learning look forward to the development of similar summer courses in the mountain area. Science requirements in the fields of Botany, Zoology, and Geology could be worked out by the elementary student under the most favorable conditions and time be gained during the regular school year for other studies.

Some Aspects of the Chemical Engineering Laboratory. C. S. GROVE, JR.

The development of a good Chemical Engineering laboratory is governed by the three factors of type of experiments available, time available, and equipment available.

The preliminary work is done during the sophomore and junior years. During these years, the student studies the basic equipment used in the process industries and the special types of industrial control equipment. He also learns to use the hand and machine tools of the forge, foundry, wood, and machine shop.

Special emphasis is laid on his Chemical Engineering laboratory during his senior year. He must study the various unit processes of flow of fluids; flow of heat; crushing and grinding; mechanical separation; filtration; humidity and drying; evaporation; distillation, absorption; and extraction.

Complete technical reports are required on investigations of each. Calculations of efficiency of operation are also required. In his later work, he must design and construct some type of machinery for use under specified conditions.

During the whole course, emphasis is laid on the importance of the student's preparation for his life's work, so that, all his tests must be definitely correlated with actual plant practice and operation.

The Behavior of Chrome-Nickel Alloys in Phosphoric Acid Solutions. W. C. WALLIN and C. S. GROVE, JR.

For several years, a study of corrosion has been carried on in the Chemical Engineering laboratories at N. C. State College. A definite paucity of information on the corrosion of steels in phosphoric acid solutions was shown by a study of the literature.

Fifteen samples of chrome-nickel steels were subjected to corrosion in phosphoric acid solutions of 0.1 N, 0.5 N, 1 N, 2 N, and 5 N concentra-

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tions. These tests were made under controlled conditions of temperature.

Measurements of the rate of corrosion in inches penetration per month were made in hundred hour periods. From these measurements it is concluded that:

(1) Each metal when exposed to the corroding solution reached a maximum rate of corrosion between the one hundred and two hundred hour period; (2) From the two hundred hour period on, the rate gradually diminished for each metal until some rate was reached at which corrosion proceeded fairly constantly or the rate was asymptotic to some value; (3) The amount of chromium or of nickel originally present gave no reliable indication of the behavior of the alloy when exposed; (4) The resistance of an alloy in one concentration was not a reliable index to its behavior in another concentration of phosphoric acid; and, (5) The following samples showed the best corrosion resistant properties in all of the concentrations of phosphoric acid No. D–Misco–N–10 per cent Cr and 20 per cent Ni, No. J–Calite E–18 per cent Cr and 8 per cent Ni; and No. M–Misco–C 29 per cent Cr and 9 per cent Ni.

Contact as a Stimulus to Localized Growth. W. C. GEORGE.

Localized growth, which plays such an important part in the development of organisms, is in some cases a result of pressure stimulation. Proof that localized pressure on the cambium causes localized growth in plants is to be found in various types of phenomena familiar to every woodsman. Some examples are: the ridges developed where separate tree trunks or approximately parallel limbs of the same tree have been in contact for some years, the growth of wood over stones or over planks placed as seats between trees, and the enlargements where tree trunks or limbs have been bound by vines. A case of the latter type that I have observed permitted of quantitative study. It was a sweet gum sapling closely bound by a honey-suckle vine throughout a zone 78 cm. in length. Determinations, stated in percentages, showed: the average bulk in the region of stimulation is 44 per cent greater than in the trunk below and 60 per cent greater than in the trunk just above; the average weight is increased 55 per cent over that of the trunk below and 118 per cent over that of the trunk above.

In animals too there is evidence that pressure is an effective stimulus to localized growth. For example, Fischer and Schmieden transplanted a section of a vein into the course of an artery. It took on the character of an artery, i.e., its connective tissue content increased and its muscular

walls were more than doubled in thickness. The greater pressure in the artery was doubtless the determining factor for increased thickness. According to the third of the Laws of Thoma: The growth in thickness of a vessel wall depends on the tension of the wall, which in turn is dependent upon the blood pressure and the diameter of the vessel.

The phenomenon of growth in response to pressure stimulation has various implications. Appearances suggest that pressure may be an important stimulus in certain regions of the vertebrate embryo. I will cite (1) the active proliferation in the nephrogenic cord where the metanephric evagination of the mesonephric duct presses into it, (2) the proliferation resulting in the formation of the neural crests in the region of fusion of the neural folds, (3) the origin of the mesoderm from the line of fusion of the lips of the blastopore.

In the field of abnormal development there are certain teratomas and parasitic fetuses which tend to occur along lines where fusions took place in embryonic development. A common explanation of the cause of these abnormalities is that one of two incompletely separated or too closely placed uniovular twins has been fused with an more or less completely incorporated into the body of the host twin. This interpretation is almost certainly true for some cases and may be for all. But in view of their tendency to occur along lines of fusions and in view of the proliferative stimulus exerted by contact, we cannot ignore the possibility that some of these teratological structures may be the result of a sort of abortive reproduction through a process of budding such as is common in many lower forms of animals.

The Effect upon a Cecil Clay Type of Soil from a Continuous Application of Mineral Plant Food Elements. G. M. GARREN and E. E. RANDOLPH.

The effect upon crop yields of a continuous annual application of mineral plant food elements is yet one of the unsolved problems in all its details of agricultural research. An aid in the solution of this problem would be a study of the effect upon the soil itself of such a system of fertilization. On the Piedmont Branch Station of the North Carolina Experiment Station, in Iredell county, a continuous series of fertilizer tests have been systematically conducted for 31 seasons, 1903–1933 inclusive, on a Cecil Clay type of soil. The $\frac{1}{20}$ acre plats were cultivated in a four year rotation of cotton, corn, wheat, and red clover. Each season there was applied to each crop the mineral plant food elements, alone or in combination, that would meet the plant's requirements for those elements deficient in that particular soil type. The

elements usually deficient in this type of soil are nitrogen, phosphorus, and potassium. The amounts applied each season and the total crop yields for the 31 seasons have been recorded. Among the series of plats at regular intervals are located check plats that received no fertilizer treatment. To determine the effect of this system upon the soil itself two plats as nearly adjacent as possible were selected for soil analyses. Upon one a complete fertilizer, containing all 3 elements, had been applied; the other was a check plat. A quantitative chemical analysis of the soil from these two plats were made for the 3 elements.

The effect of such a system upon crop yields will be illustrated by the yields of grain from the corn crop in the rotation. During these 31 seasons 8 crops of corn were grown in the rotation with a total yield of 731.36 pounds of grain from the fertilized plat and 199.64 pounds from the unfertilized plat. These records show a total increase of 531.72 pounds in favor of the fertilized plat—a 266.33 per centum increase due to the fertilization. Yet only a total of 4.5 pounds of nitrogen, 10.5 pounds of phosphorus pentoxide, and 2.25 pounds of potash were applied to this $\frac{1}{20}$ acre plat. These very small applications caused this very large increase in total yields. Similar results can be illustrated with any of the other crops grown in the rotation.

Three samples of soil at measured distances and at the three strata depths of 8, 6, and 6 inches were collected and mixed in a composite sample for each plat and then chemically analyzed for total nitrogen, phosphorus, and potassium. The results in percentages are tabulated below.

EFFECT UPON CECIL CLAY TYPE OF SOIL OF LONG CONTINUOUS FERTILIZATION (31 SEASONS)

STRATA	DEPTH	MINERAL PLANT FOOD ELEMENTS					
		Fertilized plat			Unfertilized plat		
		N_2	P_2O_5	K_2O	N_2	P_2O_5	K_2O
	inches	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
Top soil	8	.0786	.113	.786	.0756	.075	.54
Subsoil	6	.0653	.075	.7825	.0498	.05625	.60
Subsubsoil	6	.0453	.077	.79	.0473	.06375	.66

Be it noted that the percentages of nitrogen are practically the same for both plats. There is some increase in total phosphorus in the fertilized plat and considerable increase in total potash. The amounts of these elements naturally belonging to this type of soil were increased by

the fertilizer applications. On the check plat they were drawn upon by the crops grown thereon. Then the crops grown on the fertilized plat after exhausting the amounts artificially applied did not draw upon the natural amounts to the extent they did on the check plat. Possibly all the artificial applications were not taken up by the growing plants. Hence the difference in the percentages in the two plats. Note also that the percentage of the natural phosphorus in this type of soil is very low; the potash very high.

The Work of the Soil Erosion Experiment Station at Statesville, North Carolina. E. P. DEATRICK.

An individual frame film of the physical plant and its operation were shown, accompanied with a lecture giving the salient points. The 1931–1934 data from the control plots were graphically presented and samples of relative amounts of the soil and water run-off were exhibited.

Systematic Zoology. Z. P. METCALF.

The importance of systematic zoology was stressed and the idea was advanced that systematic zoology was not a static science and that we would never have an absolutely stable nomenclature. The following divisions of systematic zoology were proposed:—Systematics, Nomenclature, Taxonomy, and Phylogeny. In Systematics the importance of carefully prepared descriptions and illustrations was stressed. The importance of bibliographies and catalogues was discussed and descriptions and illustrations of the different types of keys were shown. Nomenclature was defined as that branch of systematic zoology which deals with names and not with the animals themselves. Selection of names should be based on laws even where the laws seem to run counter to common sense. Taxonomy was defined as that branch of systematic zoology which defines the fundamental units of the animal kingdom. Definitions were proposed for genera, species and varieties. Phylogeny was defined as that branch of systematic zoology which describes the evolutionary descent of organisms and their arrangement into some sort of system to show their interrelationships. The difficulty of reconstructing phylogenetic trees was pointed out. The past history of systematic zoology was briefly described, together with the growing complexity and difficulties encountered in dealing with the large number of genera and species. The important landmarks in the development of systematic zoology are:—1) the expression of the species concept by John Ray before 1700; 2) the development of binomial nomenclature by

Linneaus in the 10th Edition, *Systemae Naturae* in 1758; and 3) the phylogenetic concept by Lamarck in the earlier years of the 19th century. Three important historical periods may also be recognized:—1) a period of expansion from 1758 to about 1825; 2) a period of exploration from about 1800 to 1850; and 3) a period of specialization from about 1850 to the present time. In discussing the future of systematic zoology the point was stressed that it would be continually changing because there would be a constant interplay between systematic zoology and morphology, embryology, genetics, nomenclature, phylogeny, systematics, zoogeography, and taxonomy.

Silurian of Eastern Tennessee. W. F. PROUTY.

The Silurian of eastern Tennessee is best developed in the northern portion of the state and in the central portion of the "Valley and Ridge Province." In the Bays Mountain Area, chiefly in Greene and Hawkins Counties, there is a considerable development of white and red sandstone much resembling the Medina and so mapped in the Greeneville and Morristown Folios of the United States Geological Survey. These sandstones are overlain by red and gray shales and sandstones somewhat resembling the Rockwood and so mapped in the two above mentioned folios. Abundant fossils in the New Hope Area and in Blair Gap section prove these shales and sandstones to be of Cincinnatian Age. There is apparently no Silurian present in the Bays Mountain Area.

Going westward from the Bays Mountain Area ("Athens Trough") the Silurian comes in rapidly. In Stone Mountain and in Clinch Mountain in the eastern part of the "Cumberland Basin," ten and twelve miles respectively westward from Bays Mountain, both the Juniata (red Medina), and Tuscarora (white Medina) are represented by about 400′ thickness of strata. In Stone Mountain the Tuscarora is overlain by the Chattanooga Black Shale, but in Clinch Mountain, about two miles to the west, 12′ of Oriskany sandstone intervene between the Tuscarora and the black shale. In most exposures this Oriskany carries an abundant and characteristic fauna, but does not in the Bean Gap section which accounts for its not being recognized in the cross-section prepared for the transcontinental field trip.[1] The upper portion of the Tuscarora in the Bean Gap section is somewhat shaly and has been called Clinton by some geologists.

[1] Guide Book 3, Excursion A-3, XVI International Geological Congress, 1933.

Going westward from Clinch Mountain another twelve miles we find in Powell Mountain that the Medinas, both red and white (Juniata and Tuscarora) have been greatly reduced in thickness, and the latter in part replaced by the Brassfield. On the other hand the Clinton has come in and attained a thickness of more than 400′ and the overlying "Hancock" or "Sneedville" limestone, of Cayugan age, has come in and thickened to about 125′. Fifteen miles farther northwest at Cumberland Gap the Cayugan rocks have disappeared and the place of the Tuscarora between the Clinton and the Juniata has been taken by a few feet of very fossiliferous red limestone of Brassfield Age.

Going southwestwardly in Tennessee from the cross-section just described from near the Virginia border, we find a rapid thinning and disappearance of the Hancock and a general thinning of the Clinton. The Brassfield, represented by a few feet of limestone at base of the Clinton in Cumberland Gap section, thickens and replaces the Clinton and is the chief representative of the Rockwood in many of the central and southern exposures in the Eastern Tennessee Silurian belt. In this direction also the Juniata becomes very shaly and limy and loses all its Medina characteristics. In the Sequatchie Valley the thin-bedded red or red-and-buff calcareous shales of the Sequatchie formation underlying the Brassfield have their typical development. In southeastern Tennessee a cross-section of the folded Appalachians shows a less radical change in the Silurian sediments than the one described from the northern state border.

Throughout the southern border area the Chattanooga black shale immediately overlies the Rockwood, chiefly Brassfield. Eastward from Chattanooga the Silurian thickens considerably. In Oak Mountain, near Ooltewah, the Silurian reaches a thickness of nearly 1000′, Clinton at top, but chiefly Brassfield, while in the Sequatchie Valley it is less than two hundred feet thick with no Clinton represented.

Regeneration of Functional Testes in the Birds. BERT CUNNINGHAM.

Since the days of Berthold there have been repeated reports of the regeneration of the gonadal materials in the bird. Some of these may not legitimately be considered as regeneration processes, such as, for example, the appearance of a testis upon the right side of an animal which has lost through disease or operation the functional ovary of the left side. Here there is apparently the development of primitive germinal tissue which has been inhibited by the ovary, when it was properly functioning; the strange fact being that at times this tissue even though

it be in a female body, develops into a male gonad. There are records which show that this gonad functions both as an endocrine organ and as an actual producer of functional sperm. Such animals have been mated and have proved to be fertile.

As suggested, for our purposes, the above phenomena are not considered as regeneration, but the term is restricted to those cases where gonadectomy has been performed and there appears at a later time new gonadal tissue either at the original site or elsewhere within the body.

As one should naturally expect, the fact that gonad regeneration occurs, was first discovered when the so-called secondary sex characters were observed to reappear in the castrated bird. This phenomenon is endocrinal, being associated with the production of the male hormone, presumably by the interstitial tissue, which incidently is not actively involved in spermatogenesis. The evidence first to appear in the secondary sex characters of the bird is the reddening and growth of the comb. In birds of the regenerate type exploratory examination reveals masses of tissue which when histologically examined prove to be testicular and in some cases this is showing active spermatogenesis. In some of these birds the regenerated tissue comes to approximate in size and histological character the normal testis, but more often the masses are comparatively small, irregular in shape and frequently found quite distant from the original testes sites. Such bodies when smeared often show motile sperm.

The occurrence of regeneration is most often explained on the basis of an imperfect castration, the idea being that either a rudiment of a gonad was left *in situ* or else the rupture of the gonad gave an inadvertent transplant to the viscera of the operated animal. The large number of regenerates occurring in our pens, some appearing a year or more after the original operation, suggested that possibly careless technique was not altogether to blame for the appearance of regenerates in our stock. With this in mind the testes of our later capons were preserved so that in case regeneration occurred we could check our first operations.

One bird of this lot began showing regeneration about a year after castration. There was a rapid growth of comb until it approximated the cock size. Superficial examination of the testes which had been removed led us to believe that the first operation had been successful and complete. Before performing any exploratory operations, this bird through the aid of a local poultry-man, Mr. L. G. Cheek, was mated with four different lots of virgin pullets. Eggs taken from these before

mating were properly tested for fertility by incubation, and in all cases they proved infertile. The mating was then made and after five days the eggs which were collected and incubated showed fertility, the best test coming in one of the spring matings when in one lot of eggs the fertility compared favorably with the general run of eggs secured from the same stock (not same individuals) with normal cocks.

This observation means that not only has this bird been able to regenerate new tissue but it has also been able to connect this tissue with the ducts in such manner as to provide for the discharge of sperm in a normal manner. This functional regeneration has been observed by Hutt, but only when the epididymis has been uninjured and a mass of tissue equivalent to one sixth of the original testis left, presumably in contact with the epididymis. In the case reported here, examination under the binocular microscope fails to reveal any part of the testes missing, certainly there could not be so much as one twenty-fifth of the original testis left *in situ*.

The birds produced by mating this regenerate male with virgin pullets compare favorably with our normal chicks from this same stock in growth rate and appearance.

In another setting of 24 eggs about a week later there were 5 infertile eggs, 5 developed for about 7 days, two were unable to get out of the shell and 12 hatched. Of these latter 11 were healthy and normal at 10 days. In general the data for this clutch are similar to that presented above.

After these mating experiments exploratory operations were performed. The site on the right side was clean, the epididymis being observed. On the left side there was an unusually large testis, highly vascularised. It measured approximately 1.8 cm. through the short axis and 4 cm. through the long axis. A stout band of connective tissue encircled the structure midway on the long axis. The kidney overlapped the testis. Hemorrhages resulting from an effort to remove the gonad produced the death of the bird.

From these data it is evident that either this resultant testis originated from a far smaller mass of original tissue than ever observed previously or else it has originated *de novo* from some primitive tissue in the region.

An Attempt to Locate the Boundaries of the Durham Triassic Basin with a Magnetometer. W. R. JOHNSON, JR., and H. W. STRALEY, III.

This survey was undertaken to establish the practicability of determining, entirely on the basis of variations in the earth's magnetic field, the boundaries of a sedimentary series surrounded by igneous and

metamorphic rocks. It was hoped that the difference in magnetic permeability between the various kinds of rocks was such that boundary determinations could be made with sufficient accuracy for most geological purposes. The Durham Triassic basin appeared to be admirably adapted to such a study.

The geology of the area has been described by Dr. W. F. Prouty (Amer. Jour. Sci. **21**: 473–490. 1931) and others. The sedimentary rocks are arkosic sandstones, clays, conglomerates, fanglomerates, etc., cut by mafic dikes and sills, the latter particularly concentrated in the northwestern half of the basin. The sediments were derived from the igneous and metamorphic rocks directly to the northwest and southeast. The depth to the crystalline basement is more than 500 meters at Durham.

As a result of this survey the writers have concluded in the main that:

1. Were the area under sufficient cover to obliterate the surface geology, it would be impossible to determine the exact limits of the basin, although its existence could be hypothecated.

2. Only where faulting has occurred can the boundary be determined with certainty.

Solutions of a Simple Type of Stieltjes-Integro-Differential Equation. F. G. DRESSEL.

This paper presents the general solution of the equation,

$$u''(x) + l(x)u'(x) + m(x)u(x) + n(x)\int_a^b [P(t)u(t) + q(t)u'(t)]\,dB(t) = 0,$$

and also discusses the existence of solutions satisfying arbitrary initial conditions on the solution and its first derivative.

Complete Systems of Inequalities on Arithmetic Invariants of a Pfaffian System. D. C. DEARBORN.

Associated with a pfaffian system are certain arithmetic invariants. Four of these are the class p, the species σ, the half-rank ρ, and the number of independent equations γ. An attempt is made to obtain a set of inequalities which must be satisfied by these four invariants for a given system; and further, such that for any set of positive integers satisfying the set of inequalities, at least one pfaffian system having these numbers for invariants exists. It is shown that for any system

$$\gamma + 2\rho \leqq \mathrm{p} \leqq \gamma + \gamma\rho + \sigma.$$

If $\rho = \sigma$ the inequalities

$$\gamma + 2\rho \leqq p \leqq \gamma + \gamma\rho + \rho$$

form a complete set as defined. In the particular case $\rho = 1$, it is shown that

$$(\sigma - 1)(\sigma - 2) = 0$$

and that if $\sigma = 2$, $p = \gamma + 3$.

Associated Algebraic and Partial Differential Equations. JOSEPH A. GREENWOOD.

We are concerned with algebraic equations of the form

$$\sum_0^p a^{\alpha}_{i_1 \cdots i_n} x_1^{i_1} \cdots x_n^{i_n} = 0$$

and the associated partial differential equations where each term is replaced by the partial derivative of u with respect to the variables in that term. Using the products of x's into the algebraic system to correspond to taking derivatives in the other, we show the algebraic system to be inconsistent if and only if the general solution of its associated one is $u = 0$, and secondly, that the general solution of the partial differential equation system is a non-zero polynomial if and only if

$$x_1 = \cdots = x_n = 0$$

is the solution of its associated system.

On the Matric Equations $P(A,X) = 0$ and $P(X) = A$. E. T. BROWNE.

Let A be a given square matrix of order n, and let $F_i(A)$ $(i = 0, \cdots, m)$ be given polynomials in A with scalar coefficients. The purpose of this paper is to investigate the existence of square matrices X of order n satisfying the equation

$$P(A,X) = \sum_{i=0}^{m} F_i(A)\, X^{m-i} = 0.$$

In the particular case where $F_i(A)$ $(i = 0, \cdots, m-1)$ reduce to constants p_i and $F_m(A) = p_m - A$, the above equation reduces to the special case

$$P(X) = A.$$

In this paper we consider only such matrices X which are expressible as polynomials in A, and it is shown that the principal *idempotent* and

nilpotent matrices associated with A lend themselves very readily to a simple and elegant solution of the problem.

The Isothermal Elongation of a Stretched Rubber Band (Lantern). MILTON L. BRAUN.

An ordinary stationer's band was suspended in an electrically controlled heating tube of sufficient length to insure uniform temperature over the fully stretched length of the band. The temperature was held at 38 ± 1° C. A 500 g. weight was attached to the band and lowered at a rate of about 1 cm/sec. Without load the band had a length of 6.12 cm. At the moment the full load was accepted by the band its instantaneous length was observed to be 30.12 cm, showing an elongation of 24.00 cm. or 392 per cent of its original length. In one min the elongation had become 410 per cent, in one hr 435 per cent, in one day 475 per cent, in 10 days 518 per cent, and in 20 days 538 per cent. The data conform to the power law relation

$$E \text{ equals } 24.00 \text{ plus } 2.66t^{0.195}$$

where E is the elongation in cm beyond the original length of the band and where t is the time in hours from the application of the load. This relationship holds within a deviation of ±.049 cm. or 0.15 per cent for 115 observations from hours 1 to 474 when the last observation was made. The deviation for fractions of an hour is greater.

The Infrared Absorption Spectra of Acetic Acid and Acetic Anhydride. E. K. PLYLER and E. S. BARR.

Acetic acid and acetic anhydride show bands in the regions of 1.9, 2.3, 2.5 and 2.8μ. There is a slight variation in position and intensity but the two spectra are similar. In the region of 5.5μ there is an intense band in the acetic anhydride spectrum. When water is present acetic acid has a strong band at 5.7μ. A study of the intensities of these two bands made it possible to determine the time of formation of acetic acid from the anhydride and water. When 1 mole of water and 1 mole of anhydride were kept at 70°C, 50 per cent of the anhydride had reacted in 45 minutes. At 26°C the change required approximately 12 hrs. Other factors being constant, increasing the mole fraction of water increases the rate of reaction, and decreasing the mole fraction of water decreases the rate of reaction.

On the Half-lives of Potassium, Rubidium, Neodymium, and Samarium. ARTHUR RUARK and KARL H. FUSSLER.

The long apparent half-lives of K, Rb, and Nd are in striking disagreement with theory. To relieve this discrepancy, at least in part, the suggestion has often been made that their activities are due to isotopes of small abundance, having half-lives small in comparison with the apparent ones. Using data on the relative abundance of the elements, it is shown that the half-life of the active fraction of K is greater than 10^7 years, and that the active fractions of Rb, Nd, and Sm have half-lives greater than 10^8 years. It is pointed out that these activities may be caused by small radioactive fractions of well-known isotopes; RaD and stable Pb 210 constitute a similar case. Data are presented which show that it is possible for the active portions of Nd and Sm to be genetically connected.

Gassing-Voltage-Gravity-Temperature Relationships in the Lead-Acid Storage Cell. H. D. CROCKFORD and W. R. SINK.

The single electrode potentials and the voltage of the cell have been determined at various temperatures and acid gravities for the lead-acid storage cell during the gassing phase of the cell charge. The data secured add greatly to the knowledge of the gassing characteristics of this type of cell.

An Unexpected Observation on the Products of the Hydrolysis of Casein. E. W. MCCHESNEY

In the process of concentrating a solution of the barium salts of the amino acids obtained by the hydrochloric acid hydrolysis of casein, it was observed that a precipitate began to form while the solution was still quite dilute. Since none of the amino acids have been reported to have very insoluble barium salts (if we except aspartic acid), this precipitate seemed worthy of investigation. The barium was removed quantitatively; the amino acids in the filtrate were converted to their copper salts, and it was found that a large fraction of these was insoluble in water. This fraction was taken up in dilute acid, the copper was removed by means of hydrogen sulfide, and the filtrate from the cupric sulfide was evaporated to a syrup. The syrup was taken up in absolute alcohol, and was almost completely soluble. On evaporation of the alcoholic solution a waxy solid was obtained; its properties were then made the subject of further study.

The material was clearly aromatic in nature as shown by strongly positive xanthroproteic and diazo tests, yet the absence of tyrosine, tryptophane, and histidine could be demonstrated by specific quali-

tative tests. Its nitrogen was entirely in the amino form, and sparingly soluble copper and barium salts could readily be prepared. The substance was strongly acidic, took up bromine readily, and reacted apparently by substitution. These and other observations made upon the material are unexpected in the light of our present knowledge of the composition of casein, since none of the known amino acids, or seemingly any combination of them, could account for the observations.

A Color Test for the Identification of Mono-, Di-, and Trinitro Compounds. R. W. BOST and FRANK NICHOLSON.

One-tenth gram of a nitro body of the benzene series is dissolved in 10 cc of acetone; and 3 cc. of a 5 per cent solution of sodium hydroxide is added to it. At this point, mononitro compounds produce no color; dinitro compounds produce a purplish blue; while trinitro compounds produce a blood-red color. The presence of an amino, enolic, or a substituted amino group, interferes with the test. Acylation of the amino and enolic groups does not alter the inhibiting effect of these groups; but alkylation alters the inhibiting effect of an enolic group, though not of an amino group. In cases of a richly substituted nucleus, the typical color is not produced. The steric effect of the isomeric dinitrobenzenes is very noticeable.

CONSTITUTION OF THE NORTH CAROLINA ACADEMY OF SCIENCE

(*Revised to date*)

ARTICLE I

NAME AND OBJECT

Section 1. The name of this organization shall be the "North Carolina Academy of Science."

Section 2. The objects of the Academy shall be to promote study and scientific research and to furnish, so far as practicable, a means of publication of such articles as may be deemed worthy.

ARTICLE II

MEMBERSHIP AND DUES

Section 1. Any person actively interested in science or the promotion of science, may, upon nomination by two members, be elected a Member of the Academy by a majority vote of the Executive Committee, and shall be entitled to all privileges of the Academy.

Section 2. The initiation fee shall be $2.00, payable in advance, and there shall be no annual dues for the first year.

Section 3. The annual dues for old members shall be $2.00, and any person in arrears at the date of the annual meeting forfeits all privileges of the Academy.

Section 4. Any public spirited person donating one hundred dollars or more to the Academy may be elected a Patron of the Academy and shall be entitled to full privileges of membership.

ARTICLE III

OFFICERS

Section 1. The officers of the Academy shall be a President, Vice-President, Secretary-Treasurer, and an Executive Committee of six including the President, Vice-President, and Secretary, of which three shall constitute a quorum. The President and Vice-President shall be elected for one year. The Secretary-Treasurer, and three members

of the Executive Committee for three years, one of these three members to be elected each year. All officials shall be elected, by ballot, by majority vote.

Section 2. The duties of all officers shall be such as usually pertain to such positions. The term of office shall begin with the adjournment of the meeting at which the elections are held and shall expire with the adjournment of the next regular annual meeting.

ARTICLE IV

REPRESENTATIVES

Section 1. The Academy representative to the American Association for the Advancement of Science shall be elected for a two year period.

ARTICLE V

MEETINGS

Section 1. The time and place of all meetings shall be determined by the Executive Committee, but there shall be at least one meeting annually for the presentation and discussion of papers, and at least one business meeting annually.

Section 2. Two weeks notice shall be given of all meetings, and those present at such meetings shall constitute a quorum.

ARTICLE VI

PUBLICATIONS

Section 1. The official organ of the Academy shall be the Journal of the Elisha Mitchell Scientific Society, published at the University of North Carolina. The Editor of the Journal and the Secretary of the Academy shall compose the editorial board for the Academy, subject to the general control of the Executive Committee of the Academy.

ARTICLE VII

AMENDMENTS

Section 1. This constitution may be amended by a two-thirds vote of those present at any regular meeting: Provided, that such amendments be submitted in writing to the Executive Committee at least two weeks before the meeting at which action is to be taken.

BY-LAWS

1. The Executive Committee shall fill all vacancies occurring between meetings of the Academy.

2. Upon the written request of three or more members, the Secretary shall call a meeting of the Executive Committee, to consider such matters as may be laid before it, said meeting to take place within ten days from the time the request is submitted.

3. All elections to membership shall apply to the current *calendar year*, and no annual fee shall be collected for the year of such election.

4. The application for membership shall be accompanied by the initiation fee ($2.00), the same to be returned to the applicant should he not be elected.

5. Yearly dues regularly become payable on January 1st of each year.

6. The Secretary-Treasurer, during his term of office, shall not be liable for annual dues, and his necessary expenses in attending the regular meetings shall be defrayed from the treasury of the Academy.

OFFICERS OF THE NORTH CAROLINA ACADEMY OF SCIENCE, 1902–1936

1902

President.....W. L. Poteat
Vice-President.....T. G. Pearson
Secretary-Treasurer.....F. Sherman, Jr.

1903

President.....C. W. Edwards
Vice-President.....C. E. Brewer
Secretary-Treasurer.....F. Sherman, Jr.

1904

President.....Chas. Baskerville
Vice-President.....J. I. Hamaker
Secretary-Treasurer.....F. Sherman, Jr.

1905

President.....F. L. Stevens
Vice-President.....J. F. Lanneau
Secretary-Treasurer.....F. Sherman, Jr.

1906

President.....J. F. Lanneau
Vice-President.....Tait Butler
Secretary-Treasurer.....F. L. Stevens

1907

President.....Collier Cobb
Vice-President.....J. L. Lake
Secretary-Treasurer.....F. L. Stevens

1908

President.....T. G. Pearson
Vice-President.....W. C. Coker
Secretary-Treasurer.....E. W. Gudger

1909

President.....Tait Butler
Vice-President.....J. J. Wolfe
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1910

President.....W. C. Coker
Vice-President.....W. H. Pegram
Secretary-Treasurer.....E. W. Gudger

1911

President.....W. H. Pegram
Vice-President.....W. S. Rankin
Secretary-Treasurer.....E. W. Gudger

1912

President.....H. V. Wilson
Vice-President.....W. A. Withers
Secretary-Treasurer.....E. W. Gudger

1913

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Vice-President.....J. F. LANNEAU
Secretary-Treasurer.....E. W. GUDGER

1914

President.....F. SHERMAN, JR.
Vice-President.....Z. P. METCALF
Secretary-Treasurer.....E. W. GUDGER

1915

President.....J. J. WOLFE
Vice-President.....A. H. PATTERSON
Secretary-Treasurer.....E W. GUDGER

1916

President.....A. S. WHEELER
Vice-President.....W. A. WITHERS
Secretary-Treasurer.....E. W. GUDGER

1917

President.....F. P. VENABLE
Vice-President.....H. C. BEARDSLEE
Secretary-Treasurer.....E. W. GUDGER

1918

President.....W. A. WITHERS
Vice-President.....J. H. PRATT
Secretary-Treasurer.....E. W. GUDGER

1919

President.....E. W. GUDGER
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Secretary-Treasurer.....B. CUNNINGHAM

1920

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1921

President.....Z. P. METCALF
Vice-President.....J. M. BELL
Secretary-Treasurer.....R. W. LEIBY
Acting C. S. BRIMLEY

1922

President.....J. L. LAKE
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Secretary-Treasurer.....B. CUNNINGHAM

1923

President.....A. HENDERSON
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Secretary-Treasurer.....B. CUNNINGHAM

1924

President.....C. M. HECK
Vice-President.....J. P. GIVLER
Secretary-Treasurer.....BERT CUNNINGHAM

1925

President.....H. B. ARBUCKLE
Vice-President.....LULA G. WINSTON
Secretary-Treasurer.....BERT CUNNINGHAM

1926

President.....J. P. GIVLER
Vice-President.....J. O. HALVERSON
Secretary-Treasurer.....BERT CUNNINGHAM

1927

President.....BERT CUNNINGHAM
Vice-President.....F. E. RICE
Secretary-Treasurer.....H. R. TOTTEN

1928

President.....J. M. BELL
Vice-President.....W. L. PORTER
Secretary-Treasurer.....H. R. TOTTEN

1929

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Vice-President.....MISS MARY PETTY
Secretary-Treasurer.....H. R. TOTTEN

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Vice-President.....J. B. BULLITT
Secretary-Treasurer.....H. R. TOTTEN

1931

President.....W. F. PROUTY
Vice-President.....P. M. GINNINGS
Secretary-Treasurer.....H. R. TOTTEN

1932

President.....F. A. WOLF
Vice-President.....W. E. SPEAS
Secretary-Treasurer.....H. R. TOTTEN

1933

President.....J. B. BULLITT
Vice-President.....EARL H. HALL
Secretary-Treasurer.....H. R. TOTTEN

1934

President.....B. W. WELLS
Vice-President.....HELEN BARTON
Secretary-Treasurer.....H. L. BLOMQUIST

1935

President.....H. R. TOTTEN
Vice-President.....P. M. GINNINGS
Secretary-Treasurer.....H. L. BLOMQUIST

1936

President.....W. L. PORTER
Vice-President.....F. W. SHERWOOD
Secretary-Treasurer.....H. L. BLOMQUIST

MEMBERS OF THE NORTH CAROLINA ACADEMY OF SCIENCE, 1935

	DEGREES	INSTITUTION NOW IN	DEPARTMENT NOW IN
Abell, C. A.	M.F.	U.S.F.S.	Ap. F.E.S.
Abell, Mrs. C. A.	B.S.	U.S.F.S.	Ap. F.E.S.
Addoms, Ruth M.	Ph.D.	D.U.	Bo.
Anderson, D. B.	Ph.D.	S.	Bo.
Arbuckle, H. B.	Ph.D.	D.C.	C.
Barber, Lena A.	M.S.	M.	B.
Barrow, Elva	M.S.	W.C.	C.
Bartlett, Grady W.	B.S.	S.	P.
Barton, Helen	Ph.D.	W.C.	M.
Beck, Clifford K.	A.B.	H.S.	S. & M.
Beers, C. D.	Ph.D.	U.N.C.	Z.
Bigelow, L. A.	Ph.D.	D.U.	C.
Billings, W. Dwight	M.A.	D.U.	Bo.
Black, C. S.	Ph.D.	W.F.	C.
Blomquist, H. L.	Ph.D.	D.U.	Bo.
Bloxam, Percy	M.S.	S.	A.
Boggess, W. R.	A.B.	D.U.	Bo.
Boliek, Irene	M.A.	U.N.C.	Z.
Bookhout, C. G.	Ph.D.	D.U.	Z.
Boomhour, Elizabeth	M.A.	M.	B.
Boomhour, J. G.	M.A.	M.	P.
Bost, R. W.	Ph.D.	U.N.C.	C.
Bostian, C. H.	Ph.D.	S.	Z.
Bradbury, O. C.	Ph.D.	W.F.	B.
Brandt, B. B.	Ph.D.	M.G.C.	B.
Braun, M. L.	Ph.D.	Cat.	M. & P.
Brimley, C. S.		A.	Ent.
Brimley, H. H.		Mus.	
Brimley, R. F. W.	B.S.	H.S.	S. & Ath.
Browne, E. T.	Ph.D.	U.N.C.	M.
Buell, Jesse H.	M.F.	U.S.F.S.	Ap. F.E.S.
Bullard, Lena	M.A.	H.S.	S.
Bullitt, J. B.	M.A. M.D.	U.N.C.	Med.
Butts, Helen E.	Ph.D.	Wel.	Z.
Cameron, Frank K.	Ph.D.	U.N.C.	C.
Campbell, Eva	Ph.D.	G.C.	B.
Campbell, Roy J.	C.P.H.	S.C.	B.
Carlsson, Emma V.	Ph.D.	W.C.	Hy.

	DEGREES	INSTITUTION NOW IN	DEPARTMENT NOW IN
Carroll, Zoe Wells	M.A.	Ma.C.	B.
Causey, Rebecca M.	A.B.		
Chamberlain, B. R.	E.E.	S.B.T.	
Cleaver, Mary Conrad	Ph.D.	Cat.	B.
Clevenger, C. B.	Ph.D.	S.	So.
Clevenger, W. L.	M.S.	S.	D.
Coker, R. E.	Ph.D.	U.N.C.	Z.
Coker, W. C.	Ph.D.	U.N.C.	Bo.
Colby, Chas. DeWitt	M.D.	W.L.D.C.	Med.
Coldwell, Inez		W.C.	B.
Correll, Don S.	A.B.	D.U.	Bo.
Couch, J. N.	Ph.D.	U.N.C.	Bo.
Crittenden, Chas. V. V.	M.A.	W.C.	B.
Crockford, H. D.	Ph.D.	U.N.C.	C.
Cruse, Emmett E.	A.B.	Cat.	P.
Culbertson, J. W.	M.A.	U.N.C.	Med.
Cunningham, Bert	Ph.D.	D.U.	Z.
Dearborn, Donald C.	M.A.	D.U.	M.
Deatrick, Eugene P.	Ph.D.	U.S.D.A.	So.E.
Denson, Lee A.		U.S.W.B.	Sec.
Derieux, J. B.	Ph.D.	S.	P.
Dixon, A. A.	Ph.D.	S.	P.
Dodson, C. F.	M.S.	C.C.	B.
Douglas, J. M.		D.C.	P.
Dressel, F. G.	Ph.D.	D.U.	M.
Duncan, Wilbur H.	M.A.	D.U.	Bo.
Edmister, F. H.	Ph.D.	U.N.C.	C.
Edwards, C. W.	M.A.	D.U.	P.
Edwards, Margaret M.	M.A.	W.C.	H.E.
Eliason, Nancy	M.A.	H.S.	B.
Eller, Frank		Cat.	
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Emory, Samuel T.	M.A.	U.N.C.	G.
Evinger, Edgar L.	M.S.	U.S.D.A.	So.E.
Foster, Norman B.	M.S.	W.C.	
Frink, Horace W.	M.D.	U.N.C.	
Fritz, R. L.		L.R.	
Fulcher, H. E.	M.S.	D.C.	P.
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George, W. C.	Ph.D.	U.N.C.	Med.
Ginnings, P. M.	Ph.D.	G.C.	C.
Githens, Sherwood	M.A.	U.N.C.	P.
Givler, J. P.	M.A.	W.C.	B.
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Gudger, E. W.	Ph.D.	A.M.	I.
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Hargitt, George T.	Ph.D.	D.U.	Z.
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Heck, C. M.	M.A.	S.	P.
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Hill, Douglas G.	Ph.D.	D.U.	C.
Holl, Frederick J.	Ph.D.	U.B.	Z.
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Korstian, C. F.	Ph.D.	D.U.	F.
Kramer, Paul J.	Ph.D.	D.U.	Bo.
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Lasley, J. W.	Ph.D.	U.N.C.	M.
Latham, Dennis H.	M.A.	U.S.F.S.	P.P.
Lay, Mrs. George B.	M.A.		
Ledbetter, Ida B.	M.A.	Ap. S.	B.
Lehman, S. G.	Ph.D.	S.	Bo.
Lineberry, R. A.	Ph.D.	U.S.D.A.	So.
Ljung, Harvey A.	Ph.D.	Gu.	C.
Lutz, J. F.	Ph.D.	S.	So.
Lyon, Scott Cary	D.Sc.	D.C.	B.
MacCarthy, Gerald R.	Ph.D.	U.N.C.	G.
MacNider, W. de B.	M.D.	U.N.C.	Med.

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McNutt, Dorothea R.	B.S.	G.C.	B.
Mackie, E. L.	Ph.D.	U.N.C.	M.
Mann, H. B.	M.D.	U.N.C.	Med.
Manning, I. H.	M.D.	U.N.C.	Med.
Matthews, Velma	Ph.D.	Cok.	B.
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Miller, James Kyle	M.A.	H.S.	B.
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Ryburn, Wm. O.		Cat.	B.
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Sherwood, F. W.	Ph.D.	Exp.	N.
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Smith, F. F.	A.B.	Y.	F.
Smith, F. H.	M.S.	Exp.	N.
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Williams, Maude	M.A.	W.C.	Ps.
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Willis, L. G.	M.S.	S.	Ag.
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Winston, Lula G.	Ph.D.	M.	C.
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Zoeller, E. V.	P.D. Ph.G.	Phar. B.	

Code under Institution

A., N.C. Department of Agriculture
A.C.L., Atlantic Coast Line Rail Road
A.M., American Museum of Natural History
Ap.S., Appalachian State Teachers College, Boone
Cat., Catawba College
C.C., Campbell College
C. & D., N.C. Department of Conservation & Development
Clem., Clemson College
C.N., Carson & Newman College
Cok., Coker College
C.U., Cornell University
D.C., Davidson College
D.U., Duke University
E.C., Elon College
Exp., State Experiment Station
F.B.S., U. S. Fisheries Biological Station
F.M.C., Flora McDonald College
G.C., Greensboro College
G.S., N.C. Geological Survey
Gu., Guilford College
H.S., High School
K.M., Kendall Mills
L.R., Lenoir Rhyne College
M., Meredith College
Ma.C., Maryville College
M.G.C., Middle Georgia College, Cochrane, Ga.
M.H.C., Mars Hill College
Mus., State Museum
P.C., Presbyterian Church
Phar.B., North Carolina Board of Pharmacy
P.J., Peace Junior College
Q.C., Queen's-Chicora College
R.S.C., Rockefeller Sanitary Commission
S., N.C. State College
S.B.T., Southern Bell Telephone Company
S.C., Salem College
S.I., Smithsonian Institution
S.P., State Parks
U.B., University of Buffalo
U.N.C., University of North Carolina
U.S.B.F., U. S. Bureau of Fisheries
U.S.D.A., U. S. Department of Agriculture
U.S.F.S., U. S. Forest Service
U.S.W.B., U. S. Weather Bureau
W.C., Woman's College of the University of North Carolina
Wel., Wellesley College
W.F., Wake Forest College

W.L.D.C., The William LeRoy Dunn Clinic, Asheville
Y., Yale University

Code under Department

A., Agriculture
Ag., Agronomy
Ap. F.E.S., Appalachian Forest Experiment Station
Ath., Athletics
B., Biology
Beau., Beaufort Station
Bo., Botany
C., Chemistry
C.E., Chemical Engineering
D., Dairying
E., Engineering
Ed., Education
Ent., Entomology
Exp., Experiment Station
F., Forestry
Fl., Floriculture
F. & O., Food and oil
G., Geology
H.E., Home Economics
Ho., Horticulture
Hy., Hygiene
M., Mathematics
Med., Medical
N., Nutrition
P., Physics
P.P., Plant Pathology
Ps., Psychology
R., Research
S., Science
Sec., N.C. Section
So., Soils
So.E., Soil Erosion
St., Statesville
W., Wildlife
Wash., Washington, D. C.
Z., Zoology

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PROCEEDINGS OF THE ELISHA MITCHELL SCIENTIFIC SOCIETY

October 9, 1934, to May 14, 1935

354th Meeting, October 9, 1934

H. D. Crockford: *Certain Thermodynamic Studies of Lead-Acid Storage Cells.*

The heat balance relationships in the operation of the lead-acid storage cells have been studied and a thermodynamic explanation of the heating characteristics worked out. The maximum heating occurs when the gassing is most pronounced in the latter stages of the charge.

W. C. George: *The Rôle of Blood Cells in Excretion in Ascidians.*

355th Meeting, November 13, 1934

H. M. Burlage and Charles E. Brady: *The Official Sulfur Ointments and their Assay.*

The properties and uses of elemental sulphur and its three official ointments were discussed as well as the proposed assays for the same, which to date have been very unsatisfactory. The following modifications of Shulek's methods[1] have been found to be quite satisfactory and rapid:

Weigh accurately into a small beaker (50 cc. capacity) a sample of ointment equivalent to 2–4 centigrams of sulphur. Scatter on the sample 0.2 g. KCN, add 8–10 drops of water and 15 cc acetone and evaporate to dryness at a temperature sufficiently high to melt the ointment. Repeat the process of warming with acetone and subsequent evaporation twice using each time 5 cc. of the solvent. Dissolve the residue in water and filter through a small filter. Heat the fatty material remaining in the beaker with 5 cc. of water almost to boiling; cool somewhat and pass the aqueous liquid through the same filter. Repeat this procedure 3–4 times. The combined filtrates are received in a 125 cc. glass-stoppered Erlenmeyer flask, add 1 g. boric acid, and boil gently for ten

[1] E. Shulek, Pharm. Monatsh., **14**, 228–9 (1933).
E. Shulek, Z. Analyt. Chem., **62**, 337 (1923).

minutes. (If a clear filtrate is not obtained add the boric acid first, and in some cases 0.5 g. coarse pumice, boiling 10 minutes and then filtering and wash as described above.) Acidify the cooled solution (amounting to 50–60 cc.) with 5 cc. phosphoric acid (20 per cent), add bromine water dropwise until the solution is distinctly yellow. Add phenol (5 per cent) until the solution is decolorized. Shake well and set aside for $\frac{1}{4}$ hour. Add 0.5 gm. KI and allow to stand in the dark for $\frac{1}{2}$ hour keeping the flask tightly stoppered and then titrate with 0.1 N $Na_2S_2O_3$ using FRESH starch as an indicator.

1 cc. 0.1 N $Na_2S_2O_3$ = 0.01603 g. sulphur.

WALTER GORDY: *The Infrared Absorption of Solutions of Hydroxides and Hydrolyzing Salts.*

A study has been made of aqueous solutions of NaOH, KOH, LiOH, $ZnCl_2$, $ZnBr_2$, $NH_4C_2H_3O_2$, Na_2CO_3, $NaC_2H_3O_2$, $Na_2B_4O_7$, Na_2SiO_3, and $Al_2(SO_4)_3$ in the region from 0.6μ to 6.6μ. Bands were observed at 0.75μ 0.79μ, 0.87μ, 1.04μ, 1.22μ, 1.81μ, 2.30μ, 2.60μ, 3.65μ, and 5.2μ in the hydroxide solutions. These bands were at approximately the same positions for all the hydroxides, and the more intense bands were observed for concentrations down to 0.1 normal. The salt solutions were found to have bands in the same regions as the hydroxides and, in addition, bands were observed in the regions of 4.5μ and 5.6μ. Bands had been previously observed at 5.6μ in acid solutions. The bands in the region of 4.5μ were not present in either hydroxide or acid solutions and are to be attributed to energy levels characteristic of hydrolyzing salts.

From the results of the study of hydrolyzing salts, it was found possible to draw definite conclusions about the hydroxide bands at 1.81μ, 2.30μ, 2.60μ, 3.65μ, and 5.2μ and about the band in the region of 5.6μ characteristic of acid solutions. For salt solutions which gave acid reaction the absorption was great in the regions of 1.81μ, 2.60μ, 3.65μ, and 5.2μ, and the absorption in the regions of 2.30μ and 5.6μ was less intense, whereas, for salts which yield basic solutions, the bands at 2.30μ and 5.6μ were intense, and the absorption in the regions of 1.81μ, 2.60μ, 3.65μ, and 5.6μ was less intense. This intensity variation indicates that the hydroxide bands at 1.81μ, 2.60μ, 3.65μ, and 5.2μ are characteristic of the hydroxide molecule in solution, and that the band at 2.30μ is characteristic of the hydroxide ion. This variation indicates, also, that the acid band at 5.6μ is characteristic of the hydrated acid molecule rather than the H ion.

The bands at 2.30μ, 3.65μ, and 5.2μ were considered as fundamentals, and it was found possible to classify all other bands observed in hydroxide solutions as harmonics of these bands.

356TH MEETING, DECEMBER 11, 1934

J. N. COUCH: *Natural Hybrids of Septobasidium.*

ENGLISH BAGBY: *The Genesis of an Hysterical Symptom.*

It has long been known that many types of motor and sensory disorders as well as complete disease cemplexes, such as epilepsy, may operate on an organic or on a functional basis. Disorders of the latter sort are called hysterical and careful study usually reveals that they have the status of psychological reactions to situations which exist or have existed in the lives of the patients.

Hysterical phenomena appear to arise through the operation of three distinct forms of processes, as follows:—

1. An individual may persistently engage in phantasy thinking and this thinking may find unintended expression in a sustained abnormal posture. For instance, a patient, after disappointment in a love affair with a cobbler, now engages in romantic phantasies about the man and exhibits a contracture which simulates his posture when at work.

2. If a person has suffered a paralysis in connection with an intensely emotional episode, the paralysis may persist after its original organic basis has entirely ceased to be present. This is known as redintegration and was of common occurrence in the recent war. It is reported that a certain soldier became paralysed when a high explosive shell burst near him. He remained paralysed as long as he remained near the front where he could hear the sounds of explosions.

3. In most cases, hysterical symptoms have a utility; that is, through them some positive advantage is secured or some unsatisfactory life situation is avoided. A young woman exhibited hysterical pains in her chest and it appeared that through this "device" she was able to avoid the burden of excessive industrial work and also force her parents to permit her to enjoy the company of young men, a privilege which had not previously been granted to her. During a visit to a distant city, the symptoms disappeared, presumably because they were "unncessary" under the circumstances. Upon her being summoned home several weeks later, the pains reappeared. Treatment consisted in persuading the patient to establish an independent life away from home, to take a position requiring no more than reasonable hours of labor, and to have friends as she desired. This mode of life was a substitute for the hysteria and there has been no remission of symptoms in several years.

357TH MEETING, JANUARY 8, 1935

J. W. LASLEY, JR.: *On the Integration of Monge's Differential Equation.*

This differential equation was attributed to Monge by Boole. However Sylvester upon looking into the validity of this claim was unable to find any trace of the equation either in the printed work or manuscripts of Monge. Nor were the compatriots of Monge able to locate the equation. After much stir it was authenticated by an American, Beman. The present study concerns itself with a direct, and relatively simple integration of the equation. The technique involves expressing the differential equation in the form of a third order determinant, which after applications of elementary transformations leads to another third order determinant seen to be a Wronskian. By means of well known properties of this functional determinant an integration is then effected, leading to the conics as the system of integral curves.

W. F. PROUTY: *Geology of Coastal Plain.*

The Atlantic Coastal Plain from its northern terminus in Massachusetts to its passage into the Gulf Coastal Plain in Alabama is everywhere composed chiefly of unconsolidated sands, clays and marls. These stratified deposits dip gently toward the ocean with a variable slope but one greater than that of the Coastal Plain surface. Previous studies have shown[1] that the basement rock underlying the Coastal Plain has a broad arch whose axis extends across N. C. practically parallel with the Cape Fear Basin and that the Coastal Plain basement is much lower in Virginia to the northeast and in South Carolina to the southwest than is the case in North Carolina. Additional structural data concerning the Coastal Plain have been secured through magnetometer studies carried on by a field party from the University of North Carolina.[2] This survey demonstrated that in the northeastern part of South Carolina the Coastal Plain basement rock is more steeply inclined toward the Atlantic in the near coast area than it is farther inland and that the previously discovered buried Triassic deposits are in a well defined structural basin about 14 miles wide near Florence, S. C., and that this buried valley with its Triassic sediments can be traced by the magnetometer well into North Carolina. These structural conditions are shown on the left and front elevations of the block diagram, Figure 1. On the

[1] Dr. L. W. Stephenson, Bull. Geol. Soc. Am. **39**: 179, 1923.

[2] Party made up of W. F. Prouty, G. R. MacCarthy, and J. A. Alexander, Elisha Mitchell Sci. Soc. **49**: 20-21, 1933.

surface of this diagram is also shown the geological formations of the Coastal Plain of North Carolina. All formations marked with a K are of Cretaceous age. The lower formation marked Kt (Tuscaloosa formation) is non-marine in character and does not extend as far as the present coast line. The higher Cretaceous formations, the Eutaw (Ke) and the Ripley (Kr) are marine in character.

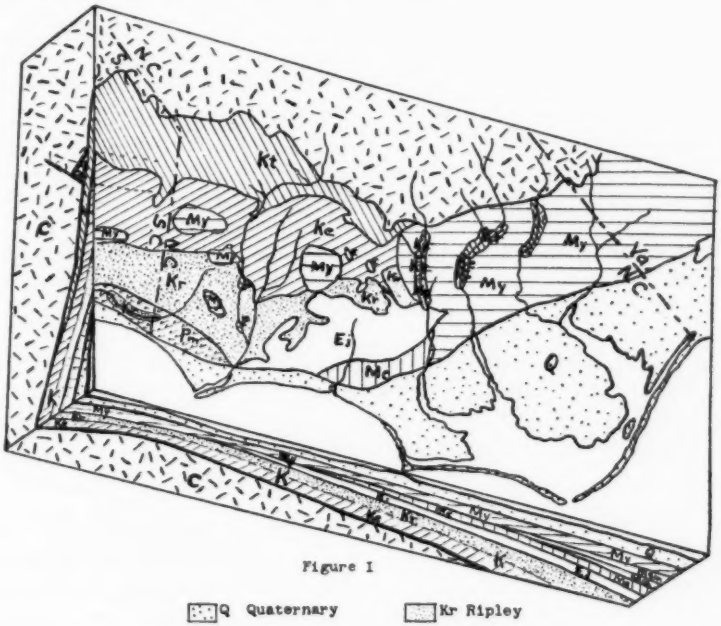

Figure 1

Q Quaternary
Pm Pliocene
My Yorktown
Mc Calvert
Ej Trent
Kr Ripley
Ke Eutaw
Kt Tuscaloosa
T Triassic
C Crystalline

The Cretaceous is best developed in the southwest half of the N. C. Coastal Plain. In the northeastern half the upper Miocene sediments cover much of the territory to the west of the Quaternary of the Pamlico and Albemarle Sound areas. In this northeastern half the Cretaceous is exposed only in places along the stream valleys. On the other hand, the upper Miocene (My) occurs in the southwestern half of the Coastal

Plain of N. C. in a few large outliers only. The Eocene (Ej) sediments are chiefly confined to the east central portion of the Coastal Plain and to a few small outliers in the western portion. One of the most interesting geological features of the Coastal Plain is the system of marine terraces having gentle oceanward slopes. This veneer of marine, sandy deposit occurs in steps or terraces which are made up along the inland border of more coarsely textured materials. These terraces represent the near shore deposits of the ocean as it stood at successively lower and lower levels during the Glacial Period. During this glacial time the coast area of N. C. must have been undergoing rather steady elevation. The old shore line which marks the ocean front at the end of Pliocene time has now an elevation of about 265′ above the present sea level. With the withdrawal of ocean water to form the first great ice sheet the ocean level was probably lowered by as much as 250′–300′. During the first interglacial time the melting ice again raised the ocean level, but due to land elevation the new shore-line was lower than the old shore-line. The above process was repeated during each of four later ice invasions and retreats. Each time the flood waters returned to form a lower-level terrace on the rising Coastal Plain.

The President announced that the committee to draw up a resolution on the death of Dr. Collier Cobb was made up of Professors W. F. Prouty, W. deB. MacNider, and H. V. Wilson. Professor Prouty then read the resolution which was as follows:

DR. COLLIER COBB

The death of Professor Collier Cobb on November 28, 1934, at Chapel Hill, N. C., has taken from the Elisha Mitchell Scientific Society one of its most loyal supporters. Professor Cobb was a constant contributor to the Society's activities and publications from the time of his appointment as Assistant Professor of Geology in the University of North Carolina in 1892 until the beginning of his final illness in 1933. A striking instance of his untiring interest in the Society was his voluntary service in the compilation of new minutes to fill a gap in the records of the Society. The gap in the records embraced a period of several years and compiling the new minutes required careful work for several months.

Professor Cobb was a native of North Carolina and was noted for his devotion to his state and its institutions, but this fact did not in any way limit his keen interest in travel and in world affairs and he was nearly as well known abroad as in the United States. His Christmas

mail always brought remembrances from people of high rank in many lands. His striking personality, keen intellect, and remarkable memory, coupled with his wealth of rare anecdotes, made him a central figure in any group.

Because of his travel and great interest in peoples and customs he will, perhaps, be best remembered in the scientific world as a human geographer. In the bibliography recently published by the Elisha Mitchell Scientific Society Professor Cobb has thirty-three listed publications. Seventeen of these dealt with human geography and nine with shoreline processes and development. Although his writings cover a wide field of thought, his greatest interest was in the work of the wind in desert and shore areas as is indicated by: "Where the Wind Does the Work," "Lands and Dunes of Gascony," and "Loess Deposits of China."

The early intellectual development of Professor Cobb was remarkable. At the age of nine he began the publication of "The Home Journal" in Shelby, North Carolina. In his tenth year he made a metrical English version of Virgil's Georgics and printed this for his friends. The early talent for writing followed him in his college career. After two years spent at Wake Forest and one at the University of North Carolina, Professor Cobb took his A. B. and M. A. degrees at Harvard. While at Harvard he furnished a number of newspapers with "associated news."

Professor Cobb was one of the great pioneers of geology in North Carolina and he enjoyed a notable record as an enthusiastic and inspiring teacher, believing that the spirit of the subject was more important than the letter, and with this same appreciation many of his students have gone out into positions of responsibility and honor.

Professor Cobb was a fellow of the Geological Society of America, and member of many societies, including the American Association for the Advancement of Science, Association of American Geographers, Boston Society of Natural History, American Institute of Mining and Metallurgical Engineers, Seismological Society of America, Elisha Mitchell Scientific Society, North Carolina Academy of Science, Sigma Xi.

Professor Cobb's knowledge of the University and of the state of North Carolina was such that he was much consulted for facts not readily obtainable elsewhere. Always a collector of books, his private library grew into one of unusual value.

The Elisha Mitchell Scientific Society has suffered a great loss by the death of Professor Collier Cobb and wishes to acknowledge and express appreciation for his active and loyal services."

358TH MEETING, FEBRUARY 12, 1935

C. W. BORGMANN: *An Optical Investigation of the Passivity of Iron in Nitric and Chromic Acids.*

It is well known that polarized light undergoes a change of state upon reflection from a metallic surface, and that this change is further influenced by the presence of a surface film. It is thus possible to determine whether or not the passivity of iron in nitric and chromic acids is due to a surface film, and finally, it is possible to measure the approximate thickness and refractive index of such a film if present.

Measurements were made on (a) fairly pure iron, (b) eutectoidic steel, and (c) austenitic stainless steel while immersed in either concentrated nitric acid or 0.01 M chromic acid. The results of the tests may be summarized briefly, as below. The natural (air-formed) oxide film on iron is replaced in nitric acid by one of 25 to 35 Ång. thick when the surface is finely polished; and by one of 80 to 100 Ång. when the surface is somewhat rough. On steel, the initial film is replaced by one of 80 to 100 Ång. thick; the nature of the surface had little influence. The film formed on the stainless steel in nitric acid is extremely thin (10 Ång.) and is perfectly protective—no growth could be measured over periods of several hours. The refractive index of the films in all cases is nearly that of ferric oxide in the bulk. The films formed on iron and steel in chromic acid are approximately the same in thickness (30 to 40 Ång.). However, the refractive index is relatively low, and thus the films are believed to be partly hydrated in this case. The results of these tests give valuable support to the oxide film theory of passivity—a theory which was first put forward by Faraday, but has only been generally accepted in very recent times.

A. S. ROSE: *The Mechanism of Visceral and Referred Pain.*

The internal organs are relatively insensitive to the usual forms of stimuli, such as, cutting, pinching, burning, etc. This lack of sensibility is due to the fact that under normal conditions the afferent neurons from the viscera do not make contact in the spinal cord with secondary neurons which carry the impulses to consciousness. Under conditions of disease, however, very severe pain may be felt. The theories for the explanation for this visceral pain are discussed. Mackenzie's theory of the pain being referred to the body surface by way of the spinal nerves, due to the production of an "irritable focus" in the spinal cord is the one most generally accepted. The clinical and experimental data which have been considered to favor this theory are presented. The micro-

scopic anatomy of the spinal cord is discussed briefly to show that the visceral afferent fibers and the afferent fibers from the body surface, mediating pain, terminate in close proximity to each other in the spinal cord. It is further pointed out that there is also a functional relationship between these fibers. Recent advances in physiology have shown that a chemical agent is used in the transfer of the effects of a nerve impulse to the active tissues, in the passage of the synapses in the sympathetic ganglia, and possibly also in the central nervous system. On the basis of these facts, it is proposed that visceral and referred pain is dependent upon the production of an abnormal amount of some chemical substance at the tip of the dorsal horn of the gray matter of the spinal cord, and the diffusion of this substance to adjacent cells whose axons travel in the pathways for pain perception.

359TH MEETING, MARCH 12, 1935

W. C. COKER: *Parasitic Flowering Plants of North Carolina.*

Colored slides were shown of all the known flowering parasites of this state except some of the smaller members of the figwort family (Scrophulariaceae). Four of these are complete parasites, such as squawroot and beech-drops. Six, while parasitic, are able to manufacture a part of their food because of their green leaves, such as mistletoe and buffalo-nut. Nineteen use animals which they kill for food, such as Venus's Fly-trap, pitcher plants, and bladderworts. All of these last have more or less chlorophyll and are therefore not completely dependent on animal food. Several additional slides of parasitic plants from foreign countries were shown for the remarkable peculiarities which they exhibit.

T. F. HICKERSON: Four Solutions of a Railroad Bent Problem.

360TH MEETING, APRIL 9, 1935

JOSEPH NISBET LECONTE: *Some Quinoline Derivatives of 2-Amino-p-cymene.* (Under the direction of Dr. A. S. Wheeler.)

A mixture of aminocymene and nitrocymene was subjected to Cohn and Gustavson's synthetic process for making quinolines. Product, 5-isopropyl-8-methylquinoline, a yellow oil; b.230-232° at 190 mm., 175° at 35 mm. This compound is reduced by sodium and alcohol to 1,2,3,4-tetrahydro-5-isopropyl-8-methylquinoline; a pale yellow oil, b.165–167° at 27 mm. The condensation of aminocymene with paraldehyde gave 2,8-dimethyl-5-isopropylquinoline; white plates, m.78°,

b.179° at 35 mm., 170° at 25 mm. When reduced with sodium and alcohol, this compound yields 1,2,3,4-tetrahydro-2,8-dimethyl-5-isopropylquinoline; white rhombic crystals, m.65°. Aminocymene and acetylacetone condensed to form acetylacetocymidide; pale yellow oil, b.184–185° at 22 mm. This, when dehydrated with sulfuric acid, forms 2,4,8-trimethyl-5-isopropylquinoline; a yellow oil, b.177–178° at 22mm. Ethyl acetoacetate condensed with aminocymene, at high temperatures, to produce acetoacetocymidide; long white needle crystals, m.235°. When dehydrated, this forms 2-hydroxy-4,8-dimethyl-5-isopropylquinoline; short white prismatic needles, shrink 225°, m.228–230°. A cymyl isatin was formed; orange-brown plates, m.174°. This compound failed to form cymyl atophan and cymyl-methyl cinchonic acid by the Pfitzinger method due to its decomposition by strong alkalies with the liberation of ammonia.

Reactions of these compounds with picric acid, methyl iodide, chloroplatinic acid, and other substances, were studied. The steric influence of substituents, and the nature of these substituents, have a marked influence on the reactions of quinoline compounds. Substituents in position 8 prevent these quinolines forming methyl iodide addition compounds. 5-Isopropyl-8-methylquinoline formed a picrate by the usual method, 2,8-dimethyl-5-isopropylquinoline and 2,4,8-trimethyl-5-isopropylquinoline with difficulty from ethereal solutions, and 2-hydroxy-4, 8-dimethyl-5-isopropylquinoline not at all. They all formed chloroplatinates except 2-hydroxy-4,8-dimethyl-5-isopropylquinoline. The derivatives made from the latter were its benzoate, m. above 322°, and 2-chloro-4, 8-dimethyl-5-isopropylquinoline, m.197°.

W. R. JOHNSON, JR., and H. W. STRALEY, III: *An Attempt to Locate the Boundaries of the Durham Triassic Basin with the Aid of a Magnetometer.*

See abstract in the Proc. N. C. Academy of Science in this issue.

361ST MEETING, MAY 14, 1935

A. E. RUARK: *The Wave-like Aspects of Matter.*

Slides showing interference phenomena were projected and the point was emphasized that the shape of interference patterns can be completely understood by the wave theory of light. Attention was next drawn to the photoelectric effect and other phenomena which can be largely understood in terms of a particle theory of light. The composite theory of Einstein, according to which the waves have no reality and

simply serve as guides for the particles, was discussed and severely criticised on the basis of its shortcomings. The modern view was then presented as follows. Light is an entity whose properties can only be studied with the aid of instruments (including the human eye), and the phenomena observed depend as much on the instrument as they do on the properties of light itself, assuming that this term has any meaning.

In the second part of the lecture, the experiments of Davisson and Germer, which led to the discovery of matter waves, were discussed in detail and a similar conclusion was drawn, to wit: matter is an entity which must be studied with the aid of instruments, and the results depend as much on the experimental apparatus as they do on the nature of matter itself, assuming for purposes of discussion that this term has any meaning. Thus, in most cases the particle aspect of matter is the only one coming to our attention, and refined experiments are required to reveal the wave-like aspects of matter which are all-important for atomic theory.

J. M. VALENTINE: *Sympathetic Evolution.*

The following officers were elected for the year 1935–1936:
President—C. D. Beers.
Vice-President—A. M. White.
Secretary-Treasurer—E. W. McChesney.
E. T. Browne, permanent secretary, and the editors of the Journal, W. C. Coker, H. V. Wilson, and Otto Stuhlman, continue in office.

SYNCYTIAL STRUCTURES IN SPONGE LARVAE AND LYMPH PLASMODIA OF SEA URCHINS[1]

By Mildred Irene Boliek

Plates 56–60

The two parts of this paper are based on very different experimental materials, sponge larvae and lymph plasmodia of sea urchins, but are one in that the questions considered are essentially those connected with the idea of cellular unity. The data here presented offer additional evidence that cells may exist as separate or partially connected bodies, or that their morphological individuality may be completely lost through the process of fusion, as in the case of the formation of lymph plasmodia, or the syncytial condition may precede a differentiation into cells, as in the sponge larvae.[2]

PART I. SYNCYTIAL STRUCTURES IN SPONGE LARVAE

Material and methods

Lissodendoryx carolinensis W. (George, W. C., and Wilson, H. V., 1919), a common silicious sponge of Beaufort (N. C.) harbor, provided the material for this investigation. This sponge breeds in summer, larvae being obtained during June and the first half of July. The larvae are cast out of the sponge mass into the surrounding water as free-swimming organisms. Consequently, the procedure of collecting the larvae

[1] A thesis submitted to the Faculty of the University of North Carolina in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Department of Zoology.

[2] The experimental part of this investigation was conducted at the United States Fisheries Biological Laboratory, Beaufort, North Carolina. I am indebted to Hon. Frank T. Bell, Commissioner of Fisheries, for the privilege of working in the Laboratory, to the Director, Dr. H. F. Prytherch, and the other members of the laboratory staff for courtesies and assistance. The Lissodendoryx material was cultured at this laboratory, 1930, 1932, by Professor H. V. Wilson. The experimental work entailed in the second part of the investigation was made possible by a grant from the Rockefeller Fund for Research in the University of North Carolina. Sincere gratitude is expressed to the committee in charge of this fund and to Professor H. V. Wilson, under whose direction the work was pursued, for helpful suggestions and constructive criticism.

is comparatively simple. The sponge containing the embryos is removed from its place of attachment, placed in an aquarium jar or porcelain-lined bucket of sea-water and allowed to remain therein until the larvae have been discharged. Liberation of the larvae usually follows shortly after the sponge is brought into the bucket or jar. The free-swimming larvae may then be picked out with a pipette and transferred to culture dishes containing fresh sea-water. They may be kept in this way for some time if the water is changed at frequent intervals. The bottom of the culture dish may be coated with paraffin in order that the metamorphosing larvae may attach and flatten out upon a stratum which can be removed from the culture without injury to the sponge. Larvae are then picked out of the cultures at intervals and preserved. Bouin's picro-formol seems to be far superior to alcohol or to Flemming's chromo-aceto-osmic acid as a fixative for the sponge tissues. Many preparations were made from the material fixed in Flemming, but in no case did the fixation seem reliable.

Histology of young free-swimming larva

The free-swimming larva is somewhat ovoid in shape, small (308μ–450μ long by 150μ–250μ wide), ciliated and motile. As is true of the larvae of related sponges, the surface layer, except at one pole (the posterior), is made up of a single stratum of elongated ciliated cells constituting an epithelium, the larval epithelium (Photograph 2, Pl. 56). In larvae kept in cultures the epithelium soon disappears at the non-spicular (anterior) pole in a great many larvae (Photographs 1, 3, Pl. 56; figs. 1, 4, Pl. 58). The disappearance of the epithelium at this pole marks an early step in metamorphosis, to which reference will be made later. The distal parts of the epithelial cells are rod-like, slender and separate, i.e., chinks are to be seen between the rods (Photograph 2, Pl. 56; fig. 10, Pl. 58). The zone of epithelial nuclei (nuclear zone) consists of 6–10 tiers of closely crowded, small (2 x 2.5μ), elliptical and non-nucleolate nuclei (Photograph 2, Pl. 56; fig. 10, Pl. 58). In my preparations it is impossible to trace a rod to a specific nucleus in the nuclear zone (zone of epithelial nuclei) (Photograph 2, Pl. 56; fig. 10, Pl. 58). As in most larvae of this type maceration preparations are necessary to show the structure of the epithelium and the various parts of the epithelial cell. Maceration preparations have been made repeatedly by Delage (1892, Pl. XIX), Maas (1892, 1893), Wilson (1894, Pl. XVI) on related sponges. Their preparations show the epithelial cell to consist of a distal rod-like portion which extends to a specific

nucleus in the nuclear zone, the cell finally losing itself in the general interior of the sponge mass. The thickness of the entire epithelial stratum of the young swimming larva is about 26–33μ. The rod portion of this stratum measuring 8–10μ, the nuclear zone the remaining 16–25μ.

The interior of the larva has generally been described as cellular (Delage 1892; Maas 1892, 1893; Wilson 1894). In normally developing Lissodendoryx larvae, and Wilson (1935) has shown that the same condition exists in *Mycale lorenzi*, the interior of the larva consists of a non-cellular, granular-reticular cytoplasm in which are imbedded two kinds of nuclei (to be described below)—a syncytium (Photographs 1, 2, 3, 4, Pl. 56; figs. 1, 2, 5, 10, Pl. 58). The nuclei are scattered in the cytoplasm and we pass directly from one nucleus to another without encountering any cell boundaries. Here and there small accumulations of fluid may interrupt the continuity of the syncytium as is shown in Photographs 2, 3, Pl. 56, but the true syncytial nature of the interior cannot be doubted if thin (3–5μ) sections of the larva be studied with the oil immersion and preferably a high (12–15K) compensating ocular. In Lissodendoryx there is no anterior watery mass of collenchyma (cavity of some writers) as is present in some sponges of this group (Mycale, Spongilla) (See Photograph 1, Pl. 56). The syncytium is uniformly dense throughout, save where interrupted by the fluid spaces (Photographs 2, 3, Pl. 56).

In one end of the larva, the end which is posterior in movement, there is present a great bundle of megascleres, long tylotes (140μ or longer) (Photograph 1, Pl. 56; fig. 26a, Pl. 59). This end of the larva is known as the spicular pole. Microscleres, sigmata (figs. 26b, d) and isochelae (fig. 26c), the small spicules of the interior, are found in the region of the spicular pole and here and there elsewhere in the interior.

At the end of the larva designated as the spicular pole, ciliated epithelium is lacking. The surface layer at this pole consists of a single layer of non-nucleolate epidermal cells which in some larvae are scarcely distinguishable, if at all, from the general syncytium of the interior. In Lissodendoryx larvae not yet liberated from the parent tissues, these epidermal cells are distinct and elongate, columnar, (fig. 3, Pl. 58); in free-swimming larvae these cells, where distinctly marked out, are flat and fusiform, as seen in longitudinal sections of the larva (right of fig. 2, Pl. 58). The transition from epithelium to epidermis is usually very abrupt (figs. 2, 3, Pl. 58).

As said above, the syncytium embraces two kinds of nuclei: nucleolate and non-nucleolate (fig. 1, Pl. 58). The nucleolate nuclei are some-

what larger (4.4μ) than the non-nucleolate (3.3μ) nuclei. Both are roughly spheroidal structures. There is no definite grouping or massing of the two kinds of nuclei in any of the larvae, but in general the nucleolate nuclei are not present in the immediate vicinity of the epithelium (figs. 5, 10, Pl. 58) nor at the spicular pole (fig. 2, Pl. 58), but are in the majority in the central portion of the larva.

Normal metamorphosis of the free-swimming larva

As already stated (p. 253), metamorphosis begins quite early at the non-spicular (anterior) pole in a number of apparently normal free-swimming larvae (Photographs 1, 3, 4, Pl. 56; figs. 4, 5, Pl. 58). In these larvae, at the designated pole, the nuclear zone of the larval epithelium thins out conspicuously (Photograph 4, Pl. 56; fig. 5, Pl. 58). In this process some of the nuclei reach the surface and are lost (fig. 4, Pl. 58); others wander into the interior where many of them die or degenerate. The thinning out process may go so far as to leave only a single layer of epithelial nuclei at this pole, these nuclei lying quite at the surface (figs. 1, 4, Pl. 58; Photograph 3, Pl. 56). Figure 5, Pl. 58, shows an earlier stage in the thinning out process: several rows of epithelial nuclei still exist in this region and pass gradually into the thicker lateral zone of nuclei (at the right of the figure).

The free-swimming phase in the development of normal larvae is, in time, a relatively short period. The larvae rapidly transform from ovoid, ciliated and motile organisms to thin, flattened and attached organisms whose expanse is 6–10 times its depth (thickness) (fig. 8a, Pl. 58). Such a transformation may come about in the course of twenty-four hours. Internal changes associated with the change in form are discussed below.

Metamorphosis of the epithelium. Flattened sponges which were picked out of the cultures at the end of twenty-four hours, fixed and sectioned show, first of all, that the epithelial stratum characteristic of of the free-swimming forms has disappeared from the surface. The disappearance of the epithelium is complete over the entire surface, i.e., no remnants of it remain (Photograph 5, Pl. 56; fig. 6, Pl. 58). The epithelial nuclei, formerly a part of the epithelial stratum, are found scattered through the interior (figs. 6, 8b, Pl. 58, representing parts of vertical sections through such sponges). The distal parts, from nucleus outwards, of the epithelial cells have completely disappeared as such—retarded larvae described below (p. 259) show them to metamorphose *in situ*, fusing with one another and the general syncytium of

the interior. The epithelial nuclei have evidently wandered into the sponge interior probably bringing some surrounding cytoplasm with them, but not in the form of cells, i.e., not as the original epithelial cells.

Formation of epidermis. There is as yet no well defined layer of cells at the surface of the flattened sponge mass (figs. 6, 8a, 8b, Pl. 58). The line which marks the surface is in most places simply the outermost layer of the syncytium (Photograph 5, Pl. 56; figs. 6, 7, 8b, 9, Pl. 58) or the limiting membrane. We might say, however, that an epidermis is forming since we find an occasional flattened epidermal (non-nucleolate) nucleus at the surface and even a well outlined flattened cell or two (fig. 6, Pl. 58), together with many rounded non-nucleolate nuclei imbedded in the syncytium a short distance below the surface (figs. 6, 8b, Pl. 58). Doubtless, these non-nucleolate (epidermal) nuclei will move to the surface and cell bodies will form round them.

Breaking up of syncytial interior into cells. The interior of a flattened larva such as is shown in photograph 5, pl. 56, and fig. 6, pl. 58, is still syncytial, i.e., we encounter no cell boundaries. In general, the syncytium is compact and continuous (Photograph 5, Pl. 56; fig. 6, Pl, 58), but there are places, in some of the twenty-four hour larvae, where watery accumulations so separate the cytoplasm into tracts as to give the appearance of vaguely outlined cells—cells with no distinct limits and as yet very much interconnected. Such places occur most frequently in the extreme periphery of the flattened mass (fig. 7, Pl. 58). This early breaking up of the cytoplasm into dense and watery tracts is, as we shall see, a preliminary step in cell differentiation.

Indeed, we find, in these flattened masses from the twenty-four hour cultures, not one but several stages in the differentiation of cells: 1) the compact, continuous syncytium with few or no watery accumulations (fig. 6, Pl. 58); 2) larvae in which watery accumulations are beginning to appear in some abundance, especially in the peripheral region (fig. 7, Pl. 58); and finally, 3) larvae which are very generally interrupted by watery spaces which mark out, more or less vaguely, cells or cell-like structures (fig. 9, Pl. 58), but the cells, although indicated, lack sharp, distinct boundaries and are, as yet, very much interconnected.

The syncytium in these last mentioned larvae is broken up by watery accumulations and by canal spaces as well (see figs. 9, 11, 12, Pl. 58). Figure 11 is indicative of the extent to which the mass is traversed by canal spaces. The canal spaces are in part simply bounded by the general syncytium, and in part imperfectly lined by non-nucleolate cells (figs. 9, 12, Pl. 58).

The nuclei found within the more or less vaguely outlined cells of these larvae are the same nucleolate and non-nucleolate types seen in preparations of the free-swimming stage. Both kinds of nuclei appear normal (healthy). Many of the epithelial nuclei, on the other hand, in the more advanced larvae are degenerate or dying and their total number is much less than one would expect if they are to participate in chamber formation. There is as yet, in the most advanced of my larvae, no grouping of epithelial nuclei to form chamber primordia.

Some of the larvae exist as rounded (ball-like), massive and still loosely attached bodies at the end of two or three days in the cultures. Sections show that they have scarcely departed from the normal course of development except that they have been slow to attach and flatten. The metamorphosis of the epithelium has proceeded as in the type, that is the rods, except here and there in one case, have disappeared and the surface layer of the larva, like the interior, is made up of a granular-reticular syncytium; the nuclear zone of epithelial nuclei has broken up, the nuclei themselves lying for the most part scattered at some distance from the surface and through the interior. In some places, however, these nuclei have approached and lie at the surface, possibly a preparatory step toward their discharge from the larva. A number of the epithelial nuclei appear abnormal but there are some good ones in the interior and still more nearer the surface. The body of the larva is syncytial. In its more superficial layer lie non-nucleolate nuclei in relatively large number. This may be regarded as a step toward the formation of the epidermis.

Quite a large number of the expanded and firmly attached larvae which were picked out of the cultures 2–3 days after their liberation as free-swimming larvae, have made little or no progress in cell differentiation and the formation of canal spaces. A particularly noticeable feature in them is the great number of degenerate epithelial nuclei in the cytoplasm (fig. 8b, Pl. 58). (Contrast in respect to this point fig. 8b with figs. 7, 9.) It could hardly be said that these particular larvae are atypical. It is rather that they are slow to undergo the changes leading to cell differentiation, and canal formation. It is quite possible that they will undergo complete metamorphosis in time.

Summary of normal metamorphosis. The metamorphosing process, in so far as it had proceeded in the larvae described, involved the following changes: (1) the attachment and flattening out of the larva; (2) the disappearance of the epithelial stratum, as such, from the surface of the sponge mass; (3) the migration of the epithelial nuclei from the region of the nuclear zone: some to the surface where they are thrown

out of the body, others into the interior of the body; (4) the metamorphosis of the rod portion of the epithelial cell *in situ*; (5) the formation, in places, of an epidermis; (6) the breaking up of the compact, continuous syncytium of the larva by watery tracts into areas which resemble cells, and indeed are cells in an early stage of differentiation. The developmental stages preserved do not proceed beyond this point.

Larvae retarded in metamorphosis and showing atypical features

In cultures which are kept from day to day, a number of the larvae fail to attach and flatten out; others attach and flatten, but are slow to undergo the changes associated with the flattening process. These retarded larvae present some phenomena of considerable interest.

Retarded larvae still free. The first group to be considered consists of free, short and thick larvae (fig. 13, Pl. 59), with an epidermal area larger than in larvae which have been recently discharged from the parent. Typical individuals measure 266.5μ x 233μ, 291.5μ x 225μ. Larvae of this kind were obtained in the cultures after 2, 3 and even 7 days. They have been figured by Wilson (1894, Pl. XVI) who thought they represented a normal, i.e., constant phase in the development. In them although unattached, the formation of the epidermis has progressed to some extent from the spicular pole forwards. Parts of longitudinal sections through such larvae are shown in photographs 6, 7, Pl. 57, and figs. 14, 15, Pl. 59.

These larvae differ from the type described as normal in that the uniform syncytium of the latter is partially broken up in the former into large and distinctly outlined cells. These cells are found especially in the vicinity of the megascleres. In the neighborhood of such an area the syncytium may be much as it was before, and the contrast between the two kinds of tissue is sharp (fig. 14, Pl. 59). This figure shows that the extreme spicular pole (right part of figure, with a distinct covering layer of epidermal cells) is dense and unbroken into cells. In it lie many non-nucleolate nuclei. In the region of the non-spicular pole the syncytium is much less dense, being more vacuolar, i.e., full of small vacuole-like spaces (Photograph 7, Pl. 57). Metamorphosis has just begun at this pole, as photograph 7 would indicate, and epithelial nuclei are moving out of the zone in which they have been aggregated: some to the surface where they are extruded (see photograph 7, Pl. 57), others into the interior.

The cells found in these larvae in the vicinity of the megascleres are large, for the most part with distinct ectoplasmic membranes and in the

main spaced well apart (Photograph 6, Pl. 57; fig. 15, Pl. 59). They are rounded or irregularly polygonal as seen in section. Their nuclei appear normal and the cytoplasm has undergone no marked change from that of the former general syncytium or remnant of the same. The great majority are nucleolate. Some of the cells or cell-like masses contain two nuclei.

These larvae do not appear to be degenerate or undergoing a slow process of death—the cytoplasm and nuclei appear normal enough, and yet the early breaking up of the syncytium before transformation of the epithelium may be a step toward degeneration, or possibly, it represents the precocious beginning of a process (breaking up of syncytium into cells) which normally occurs only after the sponge has attached and flattened out, and the epithelium has disappeared, as such, from the surface of the mass. The independence of the cells speaks for the former view.

Retarded larvae, loosely attached, still with larval shape. Some larvae were loosely attached even seven days after liberation as free-swimming forms. They had retained the larval shape, that of a short thick larva which had attached along one side. In these short, thick forms much of the epithelium has disappeared from the surface. It persists in general, at one end, that end which represents the non-spicular pole (left parts of figs. 16, 17, Pl. 59). And in some cases, small patches or areas of the epithelium had been retained on the upper surface as opposed to the surface of attachment. Between these patches, and over the surface where there is no epithelial stratum, an epidermis is forming.

The scattered remnants of the surface epithelium (found in these short, thick larvae that have been delayed in metamorphosis) show a peculiar abnormality. What we see is a surface stratum of thick blunt structures (figs. 16, 17, Pl. 59) which occupy the position of the outer parts of the rods of an earlier stage. They measure about 4.5μ in thickness and so are much thicker than the original rods. Their location, arrangement and shape show that they represent the outer ends of the original rods. The pictures indicate (compare figs. 16, 17 with fig. 14 of Pl. 59) plainly that the epithelial cells have fused with one another *in situ* except at their outer ends, the fusion having thus progressed from the interior toward the surface of the larva. Possibly the outer ends of several rods fuse to form one of the thick blunt structures, and this seems quite probable. Whereas in figure 16, pl. 59, the epithelial nuclei are no longer found massed in a zone near to the surface but are scattered in the interior, in figure 17, pl. 59, the zone of epithelial nuclei

is still recognizable and the rod structure may be here and there traced as striated material to some distance from the surface. Plainly the section (embryo) shown in figure 17 represents a stage in the metamorphosis of the epithelium earlier than that shown in figure 16.

The retention at the surface of these larvae of the thickened outer ends of the epithelium cells, while the inner cell bodies have disappeared as such, is a peculiar phenomenon which seems not to have been observed before. It is probably then to be classed, as is here done, as an abnormality, a departure from the usual course of events. The departure, however, cannot be a great one and it serves to bring out distinctly the fact that the epithelial cells do not migrate into the interior but instead, fuse with one another *in situ*.

In these larvae, the formation of epidermis goes on as in the more typical ones. In both, as the epithelial nuclei retreat from the surface, the non-nucleolate nuclei of the interior approach the surface (figs. 6, 7, Pl. 58, for the normal, figs. 16, 17, Pl. 59, for the abnormal). The non-nucleolate nuclei of the atypical larvae appear to be quite normal. They exhibit no swelling or shrinking and the chromatin is scattered in the karyolymph, not aggregated into a lump, nor condensed against the nuclear membrane. In the areas where the rods as such have quite disappeared, the non-nucleolate nuclei lie quite close to the surface, are for the most part somewhat flattened, and around them more or less flattened cell bodies are in some degree differentiated out of the general syncytium (figures just referred to). The actual emergence of epidermal cells on the surface of the larva is recorded by many observers (Goette 1886, Delage 1892, Maas 1892, 1893, Evans 1899, Wilson 1935). With the exception of Wilson they think of this as the sole process which leads to the formation of the definitive epidermis. Wilson thinks of it as only one method, finding that the method here described occurs also in his larvae (Mycale). In this research special attention was not concentrated on the question. Possibly the mass shown in fig. 17, pl. 59, surrounded by remnants of the rods, is an epidermal cell about to emerge at the surface.

The breaking up of the syncytium into independent cells noted above has progressed in these larvae to a varying extent. In some (fig. 16, Pl. 59) most of the interior still consists of a continuous, granular-reticular cytoplasm in which are scattered the three kinds of nuclei; but, in the central region, there are some, not a great many, well-defined cells and many more cells not so well defined (not shown in figure referred to). In other larvae (fig. 17, Pl. 59) while the interior is still in

part syncytial, a considerable part of the syncytium has broken up into cells, or cell-like masses often quite large which contain two, three or four nuclei. These masses may be distinctly or vaguely defined, and may hold within them a great many epithelial nuclei—all of them pycnotic (fig. 17, Pl. 59). Most of the mesenchymal nuclei within these cells and irregular cell-like masses are nucleolate, but some are non-nucleolate. Such nuclei are normal, and no evidence of degenerative change is to be observed in them. In these short, thick larvae that part of the body which represents the spicular pole consists of a dense, compact mass of cytoplasm, not yet broken up into cells and containing a great many non-nucleolate nuclei (similar to fig. 14, Pl. 59, of a retarded free-swimming larva).

Retarded larvae that have attached and flattened. Other larvae which had been kept in cultures for seven days were attached and considerably flattened, and yet showed in places remnants of the larval epithelium (Photograph 9, Pl. 57; fig. 18 1 ep, Pl. 59). Between such patches of epithelium we find an epidermis the cells of which are fairly distinct (fig. 18 ep, Pl. 59). The remnants of epithelium present much the same appearance as in the retarded larvae, just discussed, in which the body was still thick and short. That is we see at the surface thick blunt remnants of the outer ends of the rods, immediately below which there is continuous cytoplasm. Here and there (to the left, in fig. 18) these can be traced into striated material lying deeper, which obviously represents the inner parts of the rods. In the case of some of the remnants of the larval epithelium we find a condition about like that shown in figure 17, Pl. 59. That is, below the superficial remnants of the rods there are still present many epithelial nuclei, representing the earlier compact zone which has now begun to break up. In the case of other such areas there are (fig. 18, Pl. 59) almost no epithelial nuclei in the superficial region of the larva. Evidently they have migrated into the interior. In the parts of these larvae showing remnants of the larval epithelium the initial step in the formation of the epidermis had taken place. That is, epidermal non-nucleolate mesenchymal nuclei had accumulated in considerable number close to the surface (fig. 18, Pl. 59). In the regions where the metamorphosis of the epithelium is complete an epidermis of non-nucleolate cells has taken form (fig. 18, ep, Pl. 59). It is pretty well defined over the entire surface of attachment (Photograph 9, Pl. 57).

The breaking up of the syncytium into cells has progressed and there are now a great many of such cells (Photograph 9, Pl. 58; fig. 18, Pl. 59).

They are for the most part nucleolate but some are non-nucleolate. The nuclei, both nucleolate and non-nucleolate, appear quite normal. Many of the cells contain epithelial nuclei in addition to their own and in some cases the epithelial nuclei are all pycnotic, evidently dead or dying.

Summary on the breaking up of the syncytium into cells in the retarded larvae. The facts shown in figures 16, 17, 18, Pl. 59, fall into a series showing a progressive breaking up in the retarded larvae of the original syncytium into cells that have for the most part distinct ectoplasmic membranes and are independent. The more advanced stages in this process (fig. 18, Pl. 59) are conspicuously different from the the earlier syncytial stage and significantly different from the normal phase of metamorphosis described for related sponges in which the cells are in general united by strand-like inter-cellular connectives (Delage 1892, Pl. XVII; Wilson 1894, Pl. XVII). The process would seem in fact to be an abnormal step which in the end will probably lead to the death of the metamorphosing larva. The difference in structure between such larvae and more normal ones is brought out on comparing fig. 18, Pl. 59, with such sections as that shown in figure 9, Pl. 58, in which the normal cell structure is beginning to appear along with the formation of canals. The latter it will be noted have not begun to form in the atypical specimens (figs. 16, 17, 18, Pl. 59) under discussion. This abnormal breaking up of the interior into independent cells is, I take it, to be looked on as representing an early phase in a reaction of sponge larvae to unfavorable elements in the environment, a reaction which under circumstances may go much farther, as is indicated in photographs 8, 10, 11, Pl. 57, and which will be discussed later.

Oedematous unattached larvae

A small group of unattached larvae is referred to under this heading. Fluid has accumulated within these larvae filling large irregular interconnecting spaces (Photograph 11, Pl. 57), between which lies what remains of the once syncytial interior, now broken up into rounded cells with distinct outlines. These larvae were preserved two days after their liberation from parent tissues. They vary somewhat in size, but there is no great deviation from normal dimensions as the following figure would indicate: 383μ x 166.6μ; 400μ x 183μ; 375μ x 325μ. The cells of the interior form irregular, often interconnecting groups. They are spheroidal and have very distinct ectoplasmic membranes (Photograph 11, Pl. 57; fig. 22, Pl. 59). It would seem that the cells separate out of the general syncytium first along the surfaces bounding the fluid

spaces, cell formation then proceeding toward the interior of the particular syncytial mass until it is wholly or nearly broken up into cells as in photograph 11, Pl. 57, figs. 19, 20, 21, 22, 23, Pl. 59. Thus in figure 19, Pl. 59, which represents the anterior part of a longitudinal section through one of these larvae, the part of the section is bounded above (actually toward the interior of the larva) by a large irregular fluid filled space. The syncytial material bordering upon this space is evidently just beginning to break up into the spheroidal cells under discussion. Two are shown in the figure. The same fact is shown in figure 21, Pl. 59, representing the anterior end of a longitudinal section through a similar larva, in which the syncytial material immediately adjoining the fluid filled space (ffs) is obviously breaking up into cells.

Small remnants of the original syncytium remain here and there, but the greater portion of the interior is broken up into the spheroidal cells which are more or less of a size, some nucleolate an some non-nucleolate. The cytoplasm about the nuclei while granular is not so dense as the syncytial cytoplasm of the normal larva. The nuclei themselves are more or less pycnotic (fig. 22, Pl. 59), the chromatin often condensed and lying against the nuclear membrane in the form of thickenings or granules (fig. 23, Pl. 59), the inner portion of the nucleus being empty.

As is shown in photograph 11, Pl. 57, and figure 21, Pl. 59, the fluid filled spaces almost isolate a relatively thin superficial layer from the interior. This layer represents the original larval epithelium together with some of the adjoining syncytial interior. In one of the larvae patches of rods and remnants of rods are found at the surface, but elsewhere in this larva and in the other larvae the rod-like epithelial cells have disappeared as such. In some of the larvae, metamorphosis of the epithelium in certain regions apparently occurred more or less in the usual way, leaving (figs. 20, 21, Pl. 59, representing parts of longitudinal sections) a peripheral stratum of syncytial cytoplasm containing many epithelial nuclei together with some non-nucleolate mesenchymal nuclei. At the outer surface of this stratum it is clear in some cases that the syncytium is breaking up into small cells (figs. 20, 21, Pl. 59) the nuclei of which are epithelial nuclei. These are being budded off to the exterior. It is possible, perhaps probable, that the closely set projections found at the surface in places (fig. 21, Pl. 59), and into some of which epithelial nuclei are travelling, represent not new formations but the outermost remnants of rods which further inwards have fused together.

But the peripheral layer of these larvae presents in most places, as

seen in sections vertical to the surface, the appearance shown in photograph 11, Pl. 57. Here we see epithelial nuclei present in great numbers, passing out at the surface inside small rounded cells. Further in the picture is not so clear. The nuclei are possibly interconnected by syncytial cytoplasm as in figures 20, 21, Pl. 59. Or here too, they, or some of them, possibly lie in small cell bodies like those at the surface.

In general there has been no migration of the epithelial nuclei into the interior of the larvae. Only a very few of them appear there, occasionally one or two within one of the spheroidal cells of the interior. They have remained in the peripheral stratum of the larva and many, as said, are passing out at the surface into the surrounding water, not as nuclei (compare fig. 4, Pl. 58) but within cell bodies.

Pictures such as that reproduced in photograph 11, Pl. 57, leave it uncertain how far the metamorphosis, fusion *in situ* of the epithelial cells, had progressed or even whether it had started, before the abstriction of the small cells with their contained epithelial nuclei began. Possibly unlike what is shown to be going on in places represented by figures 20, 21, the long slender epithelial cells may break up directly into small nucleated portions and cytoplasmic scraps.

The tendency in these larvae to break up into independent, dissociated cells is also seen in some of them at the spicular pole (fig. 19, Pl. 59). In these cases the surface layer of the larva is budding off rounded cells, and also cell-like masses of cytoplasm in which no nucleus is apparent. The nuclei appearing in these cells and indeed in all the cells budded off at the surface in these larvae are pycnotic: i.e., the nucleus is either represented by remnants of chromatin or the chromatin is condensed against the nuclear membrane leaving the center of the nucleus clear.

Summary. These larvae are obviously abnormal and in a pathological state. How long they might have lived is a question, but it seems clear that they would never have been able to undergo metamorphosis. The salient feature which they exhibit is an intensification of that noted in retarded larvae, i.e., nuclei surround themselves with individually independent cytoplasmic bodies having distinct ectoplasmic membranes. But whereas in the retarded larvae this process affected only a part of the interior, in the oedematous larvae the exterior as well as the interior is involved. The whole body is breaking up into cells which with their spheroidal shape and ectoplasmic membranes agree with our general idea of the protoplasmic state best suited to withstand an injurious environment from which for the moment escape through locomotion is impossible.

The tendency to break up into independent cells is strikingly shown in sponges undergoing "reduction" in standing water or in sea water made chemically different from the normal (Metschnikoff 1879, Maas 1906, Müller 1911, Wilson 1907). In a reducing sponge while many of the cells die in the dissociative, "sauve qui peut," reaction, some come together in spots where the environment is probably more favorable than elsewhere, and passing into a new coöperative phase succeed in establishing a regenerative body (Laurent 1844, Lieberkühn 1859, Maas 1906, Müller 1911, Wilson 1907). In the lack of a better explanation, the idea may be provisionally entertained that the sponge larvae here described, are undergoing an analogous process, in response to stimuli which induce a breaking up of the whole into small independent nucleated masses, a breaking up which is adaptive in so far at least that the life of such masses is for a time prolonged and thus allowance made for the undoubtedly rare chance that they may come together again, like the cells of the reduction body, under better circumstances and establish some kind of a regenerative mass.

In the actual larvae of this investigation such regeneration would seem to be impossible since the larvae have already become pathological but could the cells shortly after their formation be separated from one another and then brought together under good conditions a regenerative body might at least conceivably be formed. This line of thinking is admittedly speculative but the breaking up of the larva into cells is a sufficiently striking phenomenon to call for speculation as to its meaning. To dispose of it as a mere mortuary phenomenon is not possible, for the question would still remain, why should not the larval body die bit by bit as it is, the protoplasm disintegrating into the surrounding water or internal fluid, instead of, first, so changing its morphological structure?

Larvae invaded by bacteria

In some of the cultures a number of attached larvae were invaded by bacteria and partially destroyed. The basal region of the sponge is most commonly affected, although the invasion may extend over most of the sponge surface. The bacteria collect about the base or the sides of the sponge, and in time gain entrance into the sponge mass. The surface layer is destroyed in the region of the infection, and thus the interior of the mass is exposed (Photographs 8, 10, Pl. 57). Much of what was the body is now occupied by fluid with abundant bacteria. The general syncytium has disappeared and cytoplasm has condensed around mesenchyme nuclei thus forming cells with very distinct ectoplasmic mem-

branes (Photograph 10, Pl. 57; fig. 24, Pl. 59). Such cells usually contain a number of degenerate epithelial nuclei (Photograph 8, Pl. 57), and we often get cells within cells (fig. 24, Pl. 59, those marked b) or cells within outer non-nucleated layers of cytoplasm. Such appearances indicate the occurrence of a form of localized digestion akin to phagocytosis. What happens seems to be this. A mesenchymal nucleus, presumably sick, along with the immediately surrounding cytoplasm is isolated from the general syncytium as a spheroidal cell in a vacuole. This we would regard as a quarantine measure taken for the protection of the larva in general. (In following out the idea of adaptive responses of protoplasm it is difficult to avoid the use of language which in itself might imply the existence of a conscious purpose in the protoplasmic mass. No such meaning is, of course, intended.) The next step would be the digestion of the isolated cell. Since this proceeds gradually, such cells are met with in several phases, varying from a normal appearance as in *b* at the upper right of figure 24 to the condition of *b* at the bottom of figure 24. The latter cell does not quite fill its vacuole and its nucleus has disintegrated. It was presumably quite dead when the larva was fixed. Now as the effect of the bacteria is increasingly felt the syncytium in general breaks up into independent cells, for the most part spheroidal, but immediately round a vacuole, with its included degenerate cell, only a layer surrounding the vacuole like a shell is cut out of the syncytium. This is sometimes nucleated and so we get the appearance shown in *b* at the bottom of figure 24, Pl. 59. But again no nucleus is to be seen in this outer layer, as in the case of several of the masses of figure 24. Some of the masses, as for instance the largest in figure 24, have a stratified appearance as if concentric layers of cytoplasm, one after the other, had been cut out of the syncytium. In most cases the original vacuole has disappeared and we simply see cell within cell, or cell within outer cytoplasmic layer. Where the bacterial invasion has destroyed the surface layer of the sponge the free rounded cells of the interior wander or are washed out of the sponge body into the surrounding water. Some of the larvae were caught and fixed at a time when this process was obviously going on. Eventually all the rounded cells or other masses must be disseminated. As already said, in the space between the rounded cells or other masses of the interior (Photograph 10; fig. 24) we find fluid with abundant bacteria. In the fluid there are also present cell fragments, remnants of nuclei, and occasional cells of obviously degenerate character (fig. 24, Pl. 59, at bottom left and right).

What has been said (pp. 264 and 265) as to the meaning of the

mortuary changes in the oedematous larvae applies with equal force to these larvae suffering in a very plain way from bacterial invasion. In both and in the retarded larvae as well, the obvious fact is that the sponge body breaks up, more or less completely, into independent cells, these eventually rounding up with conspicuous ectoplasmic membranes. And in seeking for some explanation of this behavior we seem to be driven to make use of the idea that protoplasmic behavior in general is at bottom adaptive and that sponge larvae, under conditions which make the usual life-cycle impossible, may exhibit a very simple form of this fundamental tendency.

PART II. SYNCYTIAL STRUCTURES PRODUCED BY LYMPHOCYTES OF SEA URCHINS

The cells (corpuscles) which float in the perivisceral fluid of Echinoderms have occasioned comment since the writings of Valentin (1842) and Williams (1856). The different kinds of corpuscles found herein were first described and figured by Geddes (1880), and soon after by Cuénot (1891). Since the work of Geddes many investigators have come to study the corpusculate fluid of the Echinoderms and other invertebrates.

Cellular elements floating in the perivisceral fluid

Geddes (1880) describes and figures for a regular sea urchin, *Echinus sphaera* or *Toxopneustes lividus* five kinds of cells. Cuénot (1891:614) recognizes the same cells and groups them as amoebocytes and vibratile corpuscles. I find in this study of the cellular elements contained in the perivisceral fluid of *Lytechinus variegatus* five distinct kinds of cells which undoubtedly correspond to those described by Geddes, Cuénot, Kindred and other investigators. (1) The most striking cell element (corpuscle) in the freshly extracted fluid is the amoebocyte with red inclusions (spherules of Kindred), first discovered by Erdl (1846) and described by all subsequent authors. These cells are more or less spherical structures, measuring 12–13μ across, with clear ectoplasmic membrane, and closely crowded, rounded spherules which obscure the nucleus (fig. 1, Pl 60). (2) Another conspicuous element in the perivisceral fluid of *Lytechinus variegatus* is the amoebocyte with colorless, refringent spherules (fig. 2, Pl. 60). This cell presents the same appearance as to size and shape as does the pigmented cell; the size of its spherules, however, slightly exceeds those of the red cells. (3) Another type of amoebocyte resembling the first two, save for its size and the

color of its spherules, is less abundant than either the red or the colorless cell. These are the yellow-green amoebocytes, about 6μ in diameter (fig. 3, Pl. 60). Most investigators believe that the yellow-green cell is but a phase of the red amoebocyte (See Geddes, Cuénot, Kindred, etc.).

(4) The fourth kind of amoebocyte found in the perivisceral fluid of Lytechinus is the leucocyte, a term first used by Goodrich (1919) and later by Kindred (1921, 1924) for this kind of cell. The leucocyte as it appears *in vivo*, or immediately upon its extraction shows a nucleus (6–8μ) surrounded by a relatively narrow zone of granular cytoplasm, bounded peripherally by a varying number of non-granular flaps, only the edges of which are visible with ordinary lighting (fig. 4, Pl. 60). The flaps do not lie in one plane, but go out from any part of the cell. This corpuscle was known to Geddes (1880), who observed it in *Echinus sphaera* and *Toxopneustes lividus*, but he describes it as having long, filiform and ramified pseudopodia. Cuénot (1891) too, describes the leucocyte as having very long and very numerous pseudopodia. Goodrich (1919) discovered that the real structures round the central cell body are membranous lobes passing out from the cell in different planes; and that Geddes' long filiform and ramified pseudopodia were probably only optical sections of such lobes. Kindred confirms Goodrich and speaks of these lobes as membranous flaps. Fauré-Fremiét (1927) describes the flaps as vesicular or bubble-like expansions of hyaloplasm, the contents not especially referred to. Lison (1930) regarded the flaps as vesicular, the wall made up of ectoplasm, the contents a perfectly hyaline fluid. The surface layer of the flaps in question is certainly ectoplasmic. As to the question whether they are vesicular with fluid contents, I may say that in the living preparations they certainly do not appear to be vesicular. However, while studying the living corpuscles no special attention was paid to this point, and my preparations of fixed material, as one would expect, do not permit a decision. As to the structure in general of these corpuscles, it may be added that the earlier observers who described them as provided with long, filiform pseudopodia (Geddes, Cuénot), may have been looking not at the natural phase of the corpuscle as it exists in the coelomic cavity, but at a later phase which is discussed below.

(5) The fifth and last kind of cell found in the perivisceral fluid, the vibratile corpuscle or flagellate cell, is very numerous and very active. The cell body measures 8μ in diameter, and its flagellum is four times as long (32μ). The cell body contains a small nucleus, and the sur-

rounding cytoplasm includes a number of granules or condensations of some sort. The flagellum, usually figured and described as thread or whip-like (fig. 5, Pl. 60), is in reality a thin, blade-like structure wider than the cell body and tapering distally (fig. 5′, Pl. 60). As this flagellum beats to and fro, it has the appearance of a line or thread, but if viewed with the dark field, every cell is seen to be provided with a blade-like process (figs. 5, 5′, Pl. 60). Geddes, Cuénot, Kindred, all described the vibratile corpuscle. The flattened blade-like flagellum has not previously been recorded.

Behavior of corpuscles in vitro

The behavior of the corpuscles which float in the coelomic (perivisceral) cavity may be studied microscopically *in vitro*. The test of the urchin is punctured, the perivisceral fluid is drawn up into a paraffined pipette and then quickly transferred to a slide, previously cleaned and the drop immediately covered. The hanging drop method may be used, but observations are more easily made on the former type of preparation.

The amoebocytes with the red, colorless, and yellow-green spherules (inclusions) undergo a change in form very soon after extraction. The ectoplasmic cell boundary, at some point on the cell surface, gives place to a "bleb-like" protrusion of the cytoplasm, and several such in rapid succession until the entire cell boundary, formerly so distinct as a sharp line, is now lost in low pseudopodial outgrowths which are in constant "play," i.e., changing (figs. 6a, b, c, Pl. 60). The spherules begin to move about within the cell, and soon (1–2 minutes) one of the "blebs" flows out as a longer pseudopodium (fig. 6d, Pl. 60), the spherules following. Thus we get actively amoeboid cells, in general distinctly elongated, in some cases measuring 35–48μ in length (fig. 7, Pl. 60). The nucleus of the living cell now appears as a clear space among the spherules. These amoeboid cells slip and slide over each other without any resulting fusion or coherence. They may, however, become entangled among or captured by the leucocytes (figs. 8a, 8b, Pl. 60). The cell with spherules, in its attempts to pull away from its captor, undergoes various modifications in form: flattens, elongates, becomes almost spherical, etc., while the transforming leucocyte is apparently sticky. No visible fusion occurs between these two kinds of cells, and the cell with spherules may escape its captor. Fixed preparations likewise show amoebocytes with spherules adhering to, or held by, single leucocytes or aggregates of them, but no definitely clear

instances of fusion between the cells with spherules and leucocytes, or between cells with spherules and vibratile corpuscles have been found.

As said, page 267, all the amoebocytes with spherules in a fresh drop of fluid show a more or less spheroidal shape. And in a drop which is fixed on the slide immediately upon extraction this same shape is observable for all the cells with spherules. This would suggest, at least, that the amoebocytes containing spherules exist as spheroidal structures in the coelom of the normal animal, although it is of course possible that the spheroidal shape is the result of shock and that the cells in the coelom are normally amoeboid. This seems improbable since the cells, if the drop be examined immediately, are all spheroidal. In "drop preparations" fixed 10 to 30 minutes after the fluid was extracted the cells with spherules are elongate, i.e., fixed in the amoeboid condition. Some may measure 35–48μ in length (fig. 7, Pl. 60). Many of these cells show beginning pseudopods. The pseudopod at this phase is entirely ectoplasmic, elongated and of considerable size (fig. 7, Pl. 60).

The leucocyte (amoebocyte with membranous flaps), however stable it may be *in vivo*, is very unstable *in vitro*. The membranous flaps constantly undergo changes in form: They may be produced into long processes (fig. 9c, Pl. 60), or may disappear as others enlarge and new ones take form. Very quickly, that is, within a few seconds to minutes, the leucocyte takes on another habitus. Upon reaching the surface of the slide it flattens out into a thin expansion (lamina), the whole body extended in one plane (fig. 11, Pl. 60). The nucleus of such a cell stands out as an ellipsoidal body surrounded by finely granular cytoplasm. That the leucocyte is very unstable *in vitro* the several investigators agree. Hjalmar Theél (1919–1921) describes two very dissimilar types of amoebocytes found in the perivisceral fluid of Echinoderms. These he regards as distinct in themselves and calls them "bladder-amoebocytes" and "hyalin-plasma amoebocytes." But Kindred (1924) raises the question of two possible functional states of the same cell. Fauré-Fremiét (1927) pursues the question further, and describes the leucocyte in the coelomic cavity as in the passive phase. And that designation is here adopted. Fauré-Fremiét (1927) emphasizes the immediate transformation of the passive leucocyte into the active or flattened, expanded form (his "choanoleucocyte"—a term adopted from A. Dehorne (1925).

Leucocytes come together and cohere in the passive phase (figs. 10a, 10b, Pl. 60), or in phases transitional between the passive and active condition to form aggregates of various sizes. This observation has also been made by Kindred (1924) and Lison (1930).

The flattened, laminate cells may, and often do, fuse to form bi-, tri-, and multi-nucleate masses, even extensive membranes or sheets. However, the dark field is necessary to bring out the detailed structure of these flattened cells and masses in the living condition. They stand out well in fixed preparations stained in a combination of Delafield's haematoxylin and acid fuchsin, or iron haematoxylin and acid fuchsin (figs. 12, 13, 14, Pl. 60).

In drop preparations kept alive in sea water over a period of 4, 6, 10 hours, we see stages in the formation of denser cell aggregates. The less dense of these show that actual fusion has occurred between the leucocytes of the aggregates. Fixed and stained preparations bear out this statement (See figs. 16, 17, Pl. 60).

Fixed and stained preparations are best for detailed studies on the leucocyte whether in the passive, transition, or flattened, laminate condition. The nucleus of the leucocyte so vaguely defined in the living cell, now stands out clear and distinct from the granular cytoplasm about it. The transition cell types most commonly seen are elongating cells—tapering at one pole, expanded and flattened at the other (fig. 9c, Pl. 60), or bi-polar cells tapering at both poles, the central part of the cell containing the nucleus being the widest. The tapering terminations of the cells may be withdrawn producing an almost spherical cell, or they may be extended and branched. Here, as in living preparations, the flattened cells may be seen both singly and fused. Single cells form very thin, large laminae with many slender, tapering processes (fig. 11, Pl. 60). We likewise get beautiful pictures of fusing cells (figs. 16, 17, Pl. 60), that is, of cells partially fused. More extensive membranes are seen in which no cell boundaries are discernible, the number of cells constituting the membrane indicated by the number of nuclei alone (fig. 15, Pl. 60).

The vibratile corpuscles or flagellate cells (p. 268) swim about rapidly (as may be seen in a drop preparation alive on the slide) with no rotation of the body, the flagellum beating from side to side. These cells, like the leucocytes, fuse with one another. Fusion may take place between the cell bodies which for a time are united by a bridge, as in fig. 19 in which both flagella may still be recognized. Or the flagellum of one cell may fuse at its tip with the body of another cell, as in fig. 18 where the two cells are shown separated by the length of the flagellum. In the loose complex shown in figure 20 fusion has evidently occurred in some cases by means of processes sent out from the cell bodies, in other cases between a flagellum at its tip and a cell body. No pictures indicating the fusion of the two flagella by their tips were obtained.

The complex formed by fusion of the vibratile corpuscles may be loose, as in figure 20, this condition doubtless representing an early phase in the fusion. Or the fusion may have progressed so far, the cells having been drawn together, that cell boundaries only exist in a very partial degree, as in fig. 21, where in the case of some cells there is no separation at all between the original bodies while in other cases the cell bodies are separated, but only imperfectly, by vacuole-like spaces.

Fusion may occur between very many of these cells in such a way as to establish beautiful reticula (fig. 20, Pl. 60). Vibratile cells, unlike the leucocytes, are slow to fuse, remaining active for some hours (four, six, or more hours).

The fusion of vibratile corpuscles, i.e., flagellate cells, has not been described by the authors cited, nor have I found any reference to it in the literature.

Behavior of the corpuscles, as learned from sections, when aggregated into dense masses

The histological question of primary interest in the aggregation of cells, whether the aggregate be massive or a thin flattened expansion, is whether the cells actually undergo cytoplasmic fusion or merely cohere. A brief review of the literature bearing on this problem is here inserted.

Geddes and all subsequent authors grant to the leucocytes the property of aggregation or agglutination, but opinions differ as to whether actual fusion of cells occurs within the aggregate. Geddes (1880) presents an interesting, and, I believe, accurate account of plasmodium formation, i.e., complete cytoplasmic fusion of the amoebocytes (leucocytes). Plasmodia, so formed, he says, contain the amoebocytes with granules (spherules, inclusions). Cuénot (1891) says, amoebocytes "unite by their long pseudopodia and form large plasmodia visible to the naked eye, which include all of the floating corpuscles save the vibratile corpuscles." Michel (1888), studying the lymph cells of Lumbricus, endeavors to disprove "the reality of a complete fusion into a plasmodium." He agrees that the lymph cells undergo a change in form on contact with air, elongate, ramify, and adhere to form masses which either die at the end of several to twenty-four hours, or dissociate into distinct rounded elements, each with a nucleus. Theél (1896) made the same observations as Geddes and Cuénot. Goodrich (1919) agrees with Michel "that the cells do not really lose their identity (1888:22), are merely connected by their hyaline ectoplasmic layer,

and are capable of resuming their independence under certain conditions." Kindred (1921), studying Arbacia, makes this statement: "I was unable, however, to observe whether or not the leucocytes formed true plasmodia or only *aggregate* plasmodia." He may be quoted as saying in 1925 "Another activity of the leucocytes is the formation of plasmodial masses . . . formed by the fusion of active leucocytes," but the observations recorded do not make evident such a conclusion. Fauré-Fremiét (1925) describes, for *Arenicola marina*, the transformation of leucocytes from passive to active phase, and the agglutination of these cells to form aggregates or masses. He finds no actual cell fusion in the mass. And he states that the constituent elements of the mass tend to recover their specific morphological characters. In his comprehensive work of 1927 (dealing with many invertebrate types: *Arenicola marina, Amphitrite Johnstoni, Nereis, Glycera, Lumbricus, Maja squinado, Phascolosoma, Asterias rubens, Marthasterias glacialis, Asterina gibbosa, Paracentrotus lividus, Echinocardium cordatum, Synapta inhaerens, Mya, etc.*) I cannot find a definite statement as to whether actual cytoplasmic fusions take place or not, i.e., fusions between the leucocytes. His statement to follow would suggest that complete fusion does not occur. He says the agglutinated masses remain perfectly alive, and the amoebocytes are capable of returning to their initial state. A more recent investigator, Lison (1930), agrees with Fauré-Fremiét as to the reversibility of the transformation from passive to active phase. He says, however, some cells never return to the passive (quiescent) state but remain elongate and anastomose with other cells of the same type to form a kind of reticulum. But he thinks it probable that these cells die before being able to return to the passive state. My observations here recorded are in line with those of Geddes and Cuénot, as regards the complete cytoplasmic fusion of leucocytes to form a multi-nucleate mass (syncytium).

As already said, the leucocytes come together and cohere in the passive and transitional phases. Actual fusion between the leucocytes occurs, as recorded, in the active phase. Perivisceral fluid when transferred from the perivisceral cavity to an open watch glass containing filtered sea-water immediately forms a "ropy" mass which can be induced to form rounded aggregates (balls) of various sizes, simply by shaking the glass so as to bring the cells and small aggregates together. Or if the fluid be allowed to stand in the watch glass, small aggregates of cells form on the bottom of the glass and fusions occur between the aggregates which approximate each other, much as between the denser

aggregates on the slide (drop preparations). Such masses, especially the larger ones, can be kept alive and healthy in filtered sea-water for one week and longer. I have kept them two weeks. These larger, rounded masses, if they come to lie near one another, fuse or merge into a single mass by means of filose pseudopodia which project from each mass. This has been described by Ward (1933). (Ward describes this phenomenon as occurring during the first day after the lymph was extracted. I have found the seven day masses merging to form a single mass and continuing to live for another week.)

The spheroidal or sub-spheroidal masses (one to several millimeters in diameter), so formed, were preserved (in Bouin) at intervals ranging from 5 minutes to 7 days after the fluid was extracted, sectioned (2–4μ), stained (Delafield's haematoxylin and acid fuchsin or iron haematoxylin and acid fuchsin), and mounted. A mass preserved 5 minutes after the extraction of the perivisceral fluid shows an interior of leucocyte tissue in which amoebocytes with spherules and vibratile corpuscles are held. The leucocyte nuclei are strewn in a reticular material, the strands of which are coarser and more deeply stained, finer and less deeply stained (fig. 22, Pl. 60). The fine strands occupy meshes made by the coarser. But there are meshes of considerable size containing no visible structures. In places the picture might be taken to indicate that cells are still marked out, perhaps imperfectly fused. But in many places this is not so, and the nuclei lie distributed in a reticulum which seems to be perfectly continuous. In this tissue then, we see strands and meshes larger and smaller. The strands coarser and finer represent the cytoplasm to which will often be added an additional aggregation of cytoplasm immediately around the nucleus. Thus in this tissue the total amount of cytoplasm as compared with vacuolar space is relatively small.

The meshes of the reticulum decrease in size, and the network gradually becomes more uniform. This difference is noticeable in masses fixed after 10 to 30 minutes (fig. 23, Pl. 60), and much more marked in masses fixed after 4, 6, 8, 10, 12 hours. The appearance of the tissue during this period changes materially. Figure 24, Pl. 60, shows the central part of a section through a mass preserved 6 hours after the perivisceral fluid was drawn. We no longer see between and around the nuclei a reticulum of quite coarse and much finer fibers, with meshes varying correspondingly in size. Instead, we find stretching between the leucocyte nuclei a reticulum made up of strands all much alike and all delicate. In such masses the reticulum is, one would say, uniform,

the strands all fine, the meshes all small; and there is nothing which can be construed as leucocyte cell boundaries. The meshes become progressively smaller as the masses grow older. And in masses which were kept alive and fixed after 2, 4, 6 and 7 days, the cytoplasm is very dense, and looks granular, becoming more and more so with the length of life of the mass. Thus in these older masses we find a dense syncytium of granular appearance in which nuclei lie scattered. A discussion of the vibratile corpuscles and cells with spherules held in the leucocyte tissue will follow.

The vibratile cells may be distinguished from leucocyte tissue by reason of their affinity for Delafield's haematoxylin. In the earlier masses these cells lie scattered throughout the mass, singly or occasionally in groups. As the mass becomes older, we note the more frequent occurrence of groups of vibratile cells, as if preliminary to fusion between these cells. In masses of several days, extensive tracts of vibratile cell tissue are seen merged with the general syncytium. In such tracts no cell boundaries are visible.

In 5 minute masses the cells with spherules all appear as spheroidal structures. Later, we note what seems to be a wandering of these cells, in general toward the periphery of the mass. This tendency becomes noticeable in masses as early as 6 to 8 hours after withdrawal of the fluid (fig. 25, Pl. 60), and becomes more pronounced up to the 10 hour age, when we get these cells massed at the periphery (fig. 26, Pl. 60), many of them elongate as if passing out from this zone. In some of the masses we found the margin surrounded by cells, as if they had already left the mass. In masses of 12 hours, we see fewer of these cells at the periphery, and while some of them, here and in the interior, retain their individuality, others are represented by irregular groups of spherules not marked off from the general cytoplasm. Also, there is to be seen an occasional cell of this type in a vacuole. In considerably older masses (2, 4 days), more and more groups of spherules occur free in the general syncytium. The spherules now vary greatly in size, some much larger than the original ones, others smaller grading down to mere granules. Doubtless then as the cell loses its identity, fusion between some of the inclusions occurs, larger bodies thus being formed while digestion would account for the diminutive size of others (fig. 29a, Pl. 60). In still older masses (6 and 7 days) cells with spherules are virtually absent, and in their place we find only scattered spherules grading down to granules (fig. 29b, Pl. 60). The pictures then indicate that a considerable number of the cells with spherules escape from the

mass, but that others remain in it losing their identity, their cytoplasm merging with that of the general syncytium, and the inclusions of these latter cells undergo a process of digestion.

The peripheral zone in these masses shows points of interest. The earliest masses are rough and irregular in contour, and in the masses of several hours the general leucocyte tissue at the periphery throws out delicate filose pseudopodia (fig. 27, Pl. 60). In slightly older masses of 6, 7, 8 hours we do not find the filose terminations, but in their stead a bounding line (as seen in sections) of dense cytoplasm (figs. 25, 32, Pl. 60). The surface of the 10 hour mass (fig. 26, Pl. 60), however, appears much as does that of the region of the 4 hour mass shown in fig. 27, Pl. 60. The superficial layer of cytoplasm, recorded for the 6–8 hour masses, is seldom present in masses of this age. Masses of 12 hours, on the other hand, are smooth showing a limiting membrane in most places as a line representing a layer of condensed cytoplasm (fig. 31, Pl. 60). The peripheral zone is now loosely reticulate and coarsely vacuolated, and contains considerably fewer cells with spherules than a corresponding zone of the 10 hour masses. It is evident that something has occurred within the mass to bring about this loose, vacuolated condition. And it is logical, in view of the observations, to assume that the vacuoles once held cells with spherules which migrated to and out from the periphery, leaving the reticulum loose and vacuolated. In masses of several days, the cytoplasm of the mass is dense out to the surface, and in some the peripheral zone is broken up into distinct tracts, which run parallel to the surface of the mass. These tracts may contain one, several or no nuclei, and while they bear some resemblance to the cells of an embryonic connective tissue, they do not become more distinct or more differentiated in the course of the next several days. Many of the older masses do not show these fiber-like tracts in the peripheral zone, and in view of what has been observed for the 8, 10, 12 hour masses, I feel that the breaking up of the zone in question is but the result of the migration of the cells with spherules. It may be added that there is no correlation between the tracts and the distribution of nuclei, and what resemblance the region has to cellular tissue is very superficial.

Of the previously mentioned investigators, Lison (1930) seems to be the only one who has prepared and figured section preparations of the larger cell aggregates or masses. He describes the agglutination of leucocytes in the passive phase, and the formation of a mass which appears as a solid plasmodium. His figures show the external zone of such masses to be divided into two distinct layers: a deeper fibrillar

layer oriented parallel to the surface, and a superficial layer bristling with very narrow, pointed pseudopodia anastomosing at their base to form a sort of reticulum (fig. 5, loc. cit.). The interior of the mass is so filled with coloring matter (which he had previously injected into the coelomic cavity) that its structure is hard to make out. He says cells charged with coloring matter emigrate from the deeper layer, pass across the external fibrillar layer, escape and once more become free. These emigrating elements are rounded cells with finely granular cytoplasm. He regards them as representing a phase of the leucocyte intermediate between the active amoeboid phase and the original passive phase with the "vesicular" flaps. He also says, that by the sixth day the organized structure of the mass has disappeared, the mass having broken down into separate, juxtaposed cells, almost all of which represent leucocytes in the intermediate phase.

I, on the other hand, have not been able to make any observations which would show the transformation of the leucocyte, from passive to active phase, to be a reversible phenomenon. The complete cytoplasmic fusions figured from drop preparations as well as those seen in sections would speak against the reverse transformation of active leucocytes. Nor, do I find healthy masses (denser, larger aggregates) breaking up into elements which could be regarded as the original constituents of the aggregate. I do find, however, in older masses, in which degeneration has already set in, the general syncytium breaking up into rounded elements which may contain one or more nuclei. These rounded bodies, which may be classed as cells, may be well defined or they may be less so. Some of the syncytial mass remains as it was, a syncytium (fig. 30a, Pl. 60). The cytoplasm of the cells which have separated out from the general mass is very granular, and their nuclei obviously degenerate. We often see these rounded bodies close to the surface of the mass as if they had just left it (fig. 30b). Degeneration changes are first apparent near the periphery of the mass, but in late stages of degeneration the interior is likewise affected and breaks up into rounded elements as in figure 30a, Pl. 60. Again, I say, the nuclei within the "cells" are pycnotic and the cells obviously incapable of assuming the character of the original constituents of the mass.

Conclusion

Evidence as to cell fusions obtained from sections is not always convincing, but certainly if cell boundaries existed in the leucocyte tissue or the vibratile cell tissue of the massive aggregates, they ought to be

visible. But they are not, and moreover, nothing is clearer than the pictures afforded by slide preparations (figs. 12, 13, 14, 15) showing complete cytoplasmic fusion between leucocytes and also between vibratile cells. Thus it seems quite clear that the fundamental feature in the formation of these lymph cell aggregates is syncytial fusion with the production of a plasmodium quite as Geddes thought.

Summary

1. Five kinds of cellular elements are found floating in the perivisceral fluid of *Lytechinus* (*Toxopneustes*) *variegatus:* rounded amoebocytes with red, colorless or yellow-green inclusions (spherules), amoebocytes with a varying number of membranous flaps (leucocytes), and vibratile corpuscles (flagellate cells).

2. The amoebocytes undergo changes in form shortly after their removal from the coelomic (perivisceral) cavity. Cells with inclusions (spherules) become amoeboid, slip and slide over each other with no resulting fusion or coherence; they may however become entangled among or captured by the amoebocytes with membranous flaps (leucocytes), but never fuse with them. The leucocytes take on another habitus, almost immediately upon their extraction, flattening out as very thin laminae with many processes. These cells fuse to form bi-, tri-, and multi-nucleate masses, even extensive sheets or membranes on the slide. Leucocytes cohere in the passive (quiescent) state, as well as in stages transitional between the passive and active (flattened, laminate) form. Vibratile corpuscles are very active. They fuse to form reticula and sheets of tissue composed of vibratile corpuscles alone. The flagellate cells are slow to lose their activity and to fuse.

3. Denser aggregates (lymph "balls" or masses), which have been kept alive in sea water, preserved at intervals, and then sectioned, show the series of internal changes. The question is, do the cells constituting the aggregate fuse, as do those on the slide, or are they but closely applied, later separating into cells much like those originally forming the aggregate? Section preparations of larger aggregates, fixed at intervals ranging from 5 minutes to 7 days, all show conclusively that actual fusion between the leucocytes is accomplished, and that the mass breaks up into rounded uni- or multi-nucleate masses only after degeneration has set in. These degeneration masses ("cells") bear no resemblance to the original cellular constituents of the mass. (They cannot be reconciled with the intermediate phase of the leucocytes described by Lison 1930.) The nuclei of the degeneration masses are

pycnotic, and the rounded masses in their entirety obviously degenerate. The amoebocytes with inclusions (spherules) either migrate to and out from the surface of the mass, becoming free or, remaining in the mass, lose their individuality as cells, their cytoplasm merging with that of the mass, and the inclusions are finally digested down to minute granules. Vibratile corpuscles eventually fuse and merge with the cytoplasm of the general mass.

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EXPLANATION OF PLATES 56–60

(Plates 56–59 are from *Lissodendoryx carolinensis* material; Plate 60, except for figure 14, from *Lytechinus variegatus* material. All figures of Plates 58–60 camera drawn.)

Abbreviations used in figures of plates 58–60

a-sp	antispicular pole
can	canal space
ci	cell with inclusions (spherules)
cs	coarser strands of cytoplasm
d l ep	degenerating larval epithelium
eic	emigrating inclusion cell
ep	epidermis
ffs	fluid filled space
fp	filose processes
fs	finer strands of cytoplasm
l ep	larval epithelium
lm	limiting membrane
ln	leucocyte nucleus
s	syncytium
sp	spicular pole (Pl. 58, 59), space (Pl. 60)
vc	vibratile corpuscle

PLATE 56

Fig. 1. Median longitudinal section of free-swimming larva in which the epithelium has already been lost at the non-spicular pole. Bundle of megascleres (tylotes) at spicular pole. Interior non-cellular. (16 mm. ×10.)

Fig. 2. Lateral portion from median longitudinal section of young free-swimming larva. The figure shows the non-cellular (syncytial) character of interior of mass; tiers of small, elliptical nuclei constituting nuclear zone, and rod-like portions of epithelium. In upper part of figure, a fluid space. (Oil immersion.)

Fig. 3. Portion of median longitudinal section of free-swimming larva, showing non-spicular pole; internal syncytium and nuclei; lateral epithelial stratum; metamorphosis already begun at non-spicular pole, at which end there is a single layer of epithelial nuclei lying quite at the surface. A fluid tract or two is to be noted. (Oil immersion.)

Fig. 4. Portion of median longitudinal section through non-spicular pole showing an earlier stage in metamorphosis of epithelium than that seen in figure 3: several layers of epithelial nuclei, these approaching but not lying at the surface; rod-like portions of epithelial cells still present but much shortened

and thickened; interior of the mass very dense and granular reticular (syncytial). (Oil immersion.)

Fig. 5. Vertical section of attached and flattened 24 hour larva in which the larval epithelium has completely disappeared as such. Epithelial nuclei have moved from periphery, some of them now lying in interior. Interior dense, compact, and unbroken into cells. Some epidermal cells already at surface but not a continuous stratum; surface in general bounded by a limiting membrane which is simply the outermost layer of syncytium. (Oil immersion.)

PLATE 57

Fig. 6. Lateral portion, near spicular end, of median longitudinal section of larva retarded in metamorphosis. Interior breaking up into cells in vicinity of megascleres. (Oil immersion.)

Fig. 7. Section showing non-spicular pole of same larva as in figure 6. This end unbroken into cells; its tissue vacuolated. (Oil immersion.)

Fig. 8. Region from interior of attached larva (vertical section) which has been invaded by bacteria. Interior broken up into rounded cells (mesenchymal) containing a number of epithelial nuclei. Presumably, larva had attached and flattened prior to invasion by bacteria. (Oil immersion.)

Fig. 9. Vertical section of retarded larva which had attached and flattened. Interior almost completely broken up into cells with distinct membranes; larval epithelium retained at the surface in places; between such patches of epithelium an epidermis present or in process of formation. Epidermis present over most of surface of attachment. (Oil immersion.)

Fig. 10. Portion from vertical section of attached larva invaded by bacteria. Bacteria appear in central part of photograph. Cytoplasm rounded up about nuclei to form large cells with distinct boundaries. Much of what was body now occupied by fluid and abundant bacteria. Most of the cells contain degenerate epithelial nuclei (not distinct in photograph), and we often get cells within cells. (Oil immersion.)

Fig. 11. Lateral region from median longitudinal section of free "oedematous" larva. Fluid has accumulated in these larvae, filling large interconnecting spaces, between which lies what remains of the once syncytial interior; interior now broken up into rounded cells with distinct outlines. Not only the interior but the exterior as well is in process of breaking up into cells, some of which are passing out from the mass. (Oil immersion.)

PLATE 58

Fig. 1. From a median longitudinal section of free-swimming larva showing non-spicular pole. At the left a bit of larval epithelium (*l ep*), to the right of this a single row of epithelial nuclei at or very near the surface, these nuclei indicating that metamorphosis of the epithelium at this pole is far along. Note dense, compact nature of interior and presence of non-nucleolate nuclei a short distance below surface. ×1000.

Fig. 2. From median longitudinal section through spicular pole. At the right

a bit of larval epithelium and to the left of this the unciliated spicular pole; non-nucleolate or epidermal nuclei at or very near the surface of this pole. Occasionally an epidermal cell is well marked out (right of figure). Interior of larva non-cellular and granular-reticular. ×1000.

Fig. 3. Portion of longitudinal section through spicular pole (*sp*) of a larva not yet liberated from parent tissues. At surface of this pole an epidermis consisting of elongate, columnar cells. Aside from this feature the section is similar to figure 2. ×1000.

Fig. 4. Portion from another median longitudinal section of a free-swimming larva. Region figured is from non-spicular pole and shows a single tier of epithelial nuclei at this pole. The figure is included chiefly to show extrusion of epithelial nuclei at surface. ×1000.

Fig. 5. From median longitudinal section of free larva, figuring non-spicular pole. Several tiers of epithelial nuclei present at this pole, the rods still *in situ*, though somewhat shortened and thickened. The figure represents an earlier stage in metamorphosis of the epithelium than that shown in figures 1 and 4, Pl. 58. ×1000.

Fig. 6. Portion of vertical section of attached and flattened larva. Interior of mass still syncytial, continuous and dense; limiting membrane (*lm*) in general only the outermost layer of the syncytium, but two epidermal cells are already well marked out. ×1000.

Fig. 7. Peripheral region of vertical section from attached and flattened larva, which is being broken up by watery accumulations into strands and tracts. These begin to bear a resemblance to freely connected and vaguely outlined cells. ×1000.

Fig. 8a. Diagram of vertical section of flattened attached larva figured in 8b. No cellular differentiation or canal spaces. ×102.

Fig. 8b. Portion of vertical section of flattened attached larva (diagram 8a) which has been slow to undergo cellular differentiation and formation of canal spaces. Note great number of degenerate epithelial nuclei. ×1000.

Fig. 9. Portion of vertical section of attached and flattened larva in which canal spaces have appeared. As yet no well-defined layer of cells at the surface and the limiting membrane (*lm*) which appears as a line, is but the outermost extension of the internal syncytium. Interior of mass very generally interrupted by watery spaces marking out vaguely delimited cells. Canal spaces bounded in part by the general syncytium, and in part by cells already marked out. ×1000.

Fig. 10. From lateral part of median longitudinal section of free-swimming larva showing nature of epithelium (larval epithelium). ×1000.

Fig. 11. Diagram of vertical section of flattened attached larva which has undergone some cellular differentiation and formation of canal spaces. ×102.

Fig. 12. Small portion of vertical section of flattened sponge, showing canal spaces bounded in part by cells already differentiated out of the general syncytium. ×1000.

PLATE 59

Fig. 13. Surface view of retarded free larva. Such a larva is characterized by a greater area of epidermis (light area in the figure) than is found in normally developing free larvae. *sp*: spicular pole. × 70.

Fig. 14. Portion of median longitudinal section of retarded larva, showing transition between the epidermis of spicular pole and the larval epithelium (*l ep*) found over the remaining surface of larva. Epidermis here well defined at spicular pole (compare epidermis of a normally developing free larva, fig. 2, Pl. 58); interior in vicinity of megascleres broken up into cells (unlike normal larva); these cells large and well defined; tissue nearer the spicular pole is continuous and compact. ×1000.

Fig. 15. Small region in vicinity of megascleres of a retarded larva. Part of megasclere at bottom of figure; the general syncytium almost completely broken up into cells; mesenchymal (nucleolate and non-nucleolate) nuclei within these cells. ×1000.

Fig. 16. Portion of section from retarded larva (7 days old), loosely attached along one side, and yet retaining larval shape. Region figured is near the non-spicular pole (there was early metamorphosis of epithelium at this pole in these retarded larvae); larval epithelium (*l ep*) at the left of figure; location, arrangement, and shape of the elements here show that they represent outer ends of original rods which have fused with one another from within out. Epithelial nuclei no longer massed to constitute a nuclear zone, but are scattered in interior; non-nucleolate (epidermal) nuclei at some little distance below rod remnants. ×1000.

Fig. 17. From section of loosely attached retarded larva. Portion figured shows remnants of larval epithelium at the left; some of the rods extending for some distance into the larva, others very short, wide structures; epithelial nuclei still massed near periphery, showing that the stage in metamorphosis is an earlier one than that of figure 16; non-nucleolate nuclei scattered among the epithelial nuclei; epidermis forming at right and at extreme left of figure. ×1000.

Fig. 18. Portion of vertical section of very flattened and firmly attached larva (7 days old) showing both upper and lower surfaces. Remnants of larval epithelium (*l ep*) retained in places (resembling the same shown in figures 16, 17); between such remnants epidermal cells already formed (left) or in process of formation; in region figured, almost no epithelial nuclei near the surface; non-nucleolate nuclei in considerable numbers near the surface; interior almost entirely broken up into cells in this larva, cells of same type as in figures 14, 15. ×1000.

Fig. 19. Portion of spicular pole of "oedematous" free larva, as seen in longitudinal section. Cells and cell-like masses lacking nuclei budding off at surface (bottom of figure); cells also being budded off into fluid-filled space (top of figure). ×1000.

Fig. 20. From vertical section of "oedematous" larva showing lateral surface (top of figure). Outer layer of larva, like the interior, breaking up into cells, these small and rounded containing epithelial nuclei and passing out from surface. Such nuclei, and also those in the unbroken portion of periphery all pycnotic. ×1000.

Fig. 21. From similar section through anti-spicular (non-spicular) pole (*a sp*), surface of larva at bottom of figure. A fluid-filled space (*ffs*) in interior of larva almost isolates a superficial layer from interior. This layer repre-

sents original larval epithelium together with some of adjoining syncytial interior. Here, as in figures 19, 20, cells are being budded off to exterior, and into fluid-filled space of interior; nuclei all pycnotic. ×1000.

Fig. 22. Several mesenchymal cells from interior of "oedematous" larva. Note the uniformity in shape and size and pycnotic character of nuclei. ×1000.

Fig. 23. Pycnotic nuclei from "oedematous" larvae. Smaller nuclei are epithelial; larger, mesenchymal. ×1000.

Fig. 24. Cells and masses from interior of larvae invaded by bacteria. Cells large and with distinct ectoplasmic membranes, usually containing a number of degenerate epithelial nuclei (a). We often get cells within cells, or cells within outer non-nucleated layers of cytoplasm (b). ×1000.

Fig. 25. Pycnotic epithelial nuclei from flattened attached larvae slow to undergo cellular differentiation and formation of canal spaces. ×1000.

Fig. 26a. Megascleres, tylotes. ×474.

Fig. 26b. Microscleres, sigmata. ×734.

Fig. 26c. Microscleres, isochelae. ×734.

Fig. 26d. Microscleres, sigmata. ×734.

PLATE 60

Fig. 1. Amoebocyte with red inclusions (spherules). Cell as it appears immediately upon removal of perivisceral fluid from body cavity. Living preparation. ×310.

Fig. 2. Amoebocyte with colorless inclusions (spherules), as it appears immediately upon extraction of perivisceral fluid. Spherules are somewhat larger than those in red cell (fig. 1). Living preparation. ×310.

Fig. 3. Amoebocytes with yellow-green inclusions (spherules). This cell smaller than red or colorless cell. Living preparation. ×310.

Fig. 4. Leucocyte (amoebocyte with membranous flaps) as it appears *immediately* upon extraction of perivisceral fluid. Nucleus surrounded by a number of non-granular cytoplasmic flaps, which go out from any part of cell. Flaps so transparent that it is only the edge which catches the eye. Living preparation. ×310.

Fig. 5. Vibratile corpuscle or vibratile cell as it appears with ordinary methods of illumination. Whip-like flagellum *four* times as long as diameter of cell body. Living preparation. ×480.

Fig. 5′. Vibratile corpuscle viewed with dark field. Flagellum in reality blade-like. Living preparation. ×310.

Figs. 6a, b, c, d, e. Amoebocyte in process of becoming amoeboid. First a bleb-like protrusion of the cell, consisting of non-granular, hyaloplasmic substance, is noted (a), then several blebs in rapid succession (b and c), until finally one bleb becomes larger than the others (d) and the spherules then flow into it as the cell begins to move about by amoeboid motion. The *two* cells labeled (e) are actively amoeboid cells. Living preparations. ×310 (a, b, d, e); ×480 (c).

Fig. 7. Very elongate amoebocyte with inclusions showing pseudopodium and nucleus of cell. Fixed preparation. ×656.

Fig. 8. Two figures showing amoebocyte with inclusions captured by leucocyte. Living preparation. ×310.

Figs. 9a, b, c. Early stages in transformation of leucocytes *in vitro*, as seen both in living and in fixed preparations. ×656.

Figs. 10a, b. Cohering leucocytes. Leucocytes may come together and cohere before they have changed their habitus. Fixed preparation (seen also in the living). ×656.

Fig. 11. Leucocyte which has flattened out on surface of slide. It now appears as a very thin lamina with many processes, the nucleus being surrounded by a narrow zone of granular material. Living preparation. ×656.

Fig. 12. Bi-nucleate lamina. Two leucocytes have fused. No line of demarcation between the cells, fusion complete. Fixed preparation. ×656.

Fig. 13. Tri-nucleate mass of leucocyte tissue. Complete fusion between three leucocytes. Fixed preparation. ×656.

Fig. 14. Denser aggregate or multinucleate mass of leucocyte tissue—a small "clot." Fixed preparation. (Arbacia punctata). ×656.

Fig. 15. Extensive membrane or sheet of leucocyte tissue. Number of leucocytes constituting mass indicated by number of leucocyte nuclei. There has been complete fusion of constituent cells. Fixed preparation. ×656.

Fig. 16. Two flattened, expanded cells in process of fusing. Certain of the cell processes have come in contact and there fused. Such cells would eventually become a single bi-nucleate mass. Fixed preparation. ×656.

Fig. 17. Group of *six* leucocytes which have made contact with one another and are in process of merging to form a single mass. Fixed preparation. ×656.

Fig. 18. Two vibratile corpuscles, separated by the length of the flagellum, but united. The flagellum of one has fused with the body of the other. Early step in the formation of a reticulum or sheet of tissue composed of vibratile corpuscles. Fixed preparation. ×656.

Fig. 19. Two vibratile corpuscles whose cell bodies are touching. Fusion has occurred at point of contact. Fixed preparation. ×656.

Fig. 20. Open reticulum formed by fusion of a number of vibratile corpuscles. Fixed preparation. ×656.

Fig. 21. A more dense reticulum of vibratile corpuscles. Fixed preparation. ×656.

Fig. 22. Part of section from lymph mass preserved 5 minutes after perivisceral fluid was extracted. The section shows a number of leucocyte nuclei. Between these there is material marked by irregularly coursing strands connected with one another. In the meshes formed by these strands sometimes a finer reticular structure can be made out. Elsewhere no structure is visible in the meshes. In places coarser strands bound areas which might be taken to represent leucocyte cells, but in most places cells cannot be visualized and the nuclei lie in a reticulum which seems to be perfectly continuous. In most places, a little cytoplasm appears about the leucocyte nucleus. The section shows two inclusion cells. Inclusion cells and vibratile corpuscles have preserved their individuality. ×656.

Fig. 23. Part of section of lymph mass preserved 30 minutes after perivisceral fluid was extracted. Meshes of reticulum in this section for the most part

smaller, and reticulum more obviously continuous than in the preceding. Section shows a vibratile corpuscle (*vc*). ×656.

Fig. 24. Part of section from 6 hour mass. The syncytial material now shows pretty uniform meshes, the strands all much alike and delicate. Several inclusion cells shown in figure. These cells still retain their individuality, as do also the vibratile corpuscles (*vc*). ×656.

Fig. 25. Periphery of 8 hour mass (in section). The leucocyte tissue which forms framework of mass very like that of 6 hour mass. Quite a number of cells with inclusions have come to lie near periphery. They have retained their individuality. Surface of mass made by continuous film, and in that sense is smooth, the limiting membrane being merely the outermost extension of the reticulum of leucocyte tissue. ×656.

Fig. 26. Peripheral region (in section) of 10 hour mass. The emigration of cells with inclusions to periphery, begun as early as 6 hour mass, has reached point where cells with inclusions are leaving the mass by amoeboid movement. These outwandering cells have broken the limiting membrane in a great many places and we now get filose processes at the surface. Note crowded cells with inclusions a short distance below surface of mass. ×390.

Fig. 27. Peripheral region of 4 hour mass (in section). This section figured to show that the "balls" have not yet, in places, gotten a smooth, film-like surface (fig. 25). These masses still retain in places, as figured, filose processes.

Fig. 28. Part of interior (as seen in section) of mass preserved after 2½-3 days in culture. Reticulum which now stretches between leucocyte nuclei very finely reticular. ×656.

Fig. 29a. From section of 4 day mass showing a bit of the interior. Interior very finely reticular. Cells with inclusions no longer retain their identity, i.e., the cell membranes have disappeared, and inclusions have in some cases fused (merged). The section shows a number of these masses of varying size, ranging from large to quite small structures. Two of them lie in what appear to be small collections of fluid. ×656.

Fig. 29b. From section of 6 day mass showing a bit of the interior of the mass. Interior very finely granular-reticular, and what remains of the inclusion cells lie free in the syncytium. Remnants of inclusions appear to be in the process of digestion, grading down to fine granules. ×656.

Fig. 30a. Part of section from mass (1 week old) which is dying. Section includes surface, most of which shows a continuous limiting membrane (*lm*). The now dense, granular cytoplasm of the mass, is rounding up about nuclei and forming rounded cell-like bodies. The nuclei within the cell bodies all appear pycnotic. This breaking up of interior into cells, a phenomenon associated with death of mass. ×656.

Fig. 30b. Rounded masses of cytoplasm, each containing several nuclei, lying just outside the mass shown in 30a. The nuclei within these outwandering masses are all pycnotic. ×656.

Fig. 31. Peripheral region of 12 hour mass as seen in section. Reticulum which stretches between leucocyte nuclei in this section loose and irregular. It

shows some spaces of considerable size (*sp*). The spaces apparently represent cavities in which inclusion cells lay before emigrating from the mass. Emigration of these cells would also account for the broken strands of the reticulum. Few inclusion cells now lie at the surface or in region near surface. Surface of mass again smooth, the filose processes absent. ×656.

Fig. 32. Peripheral region of older mass (4 days old) as seen in section. Surface smooth, interior unbroken (syncytial). A few cells with inclusions still lie in this region. These cells have, however, lost the cell membrane over a part or all of the surface. Section also shows a vibratile corpuscle. ×656.

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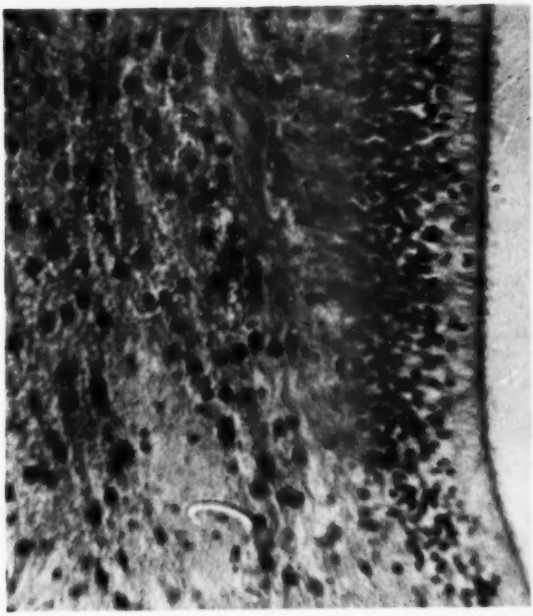

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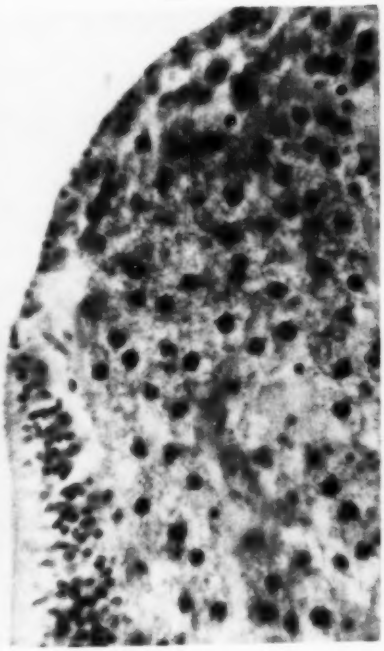

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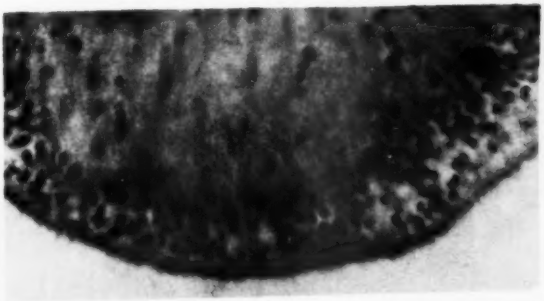

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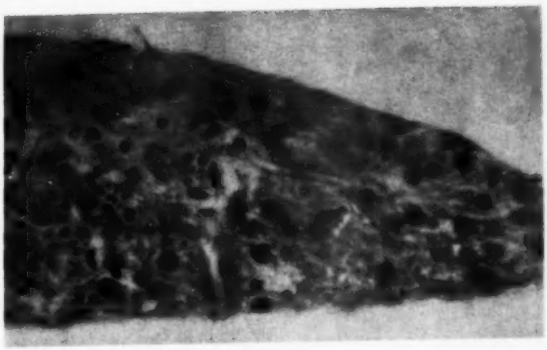

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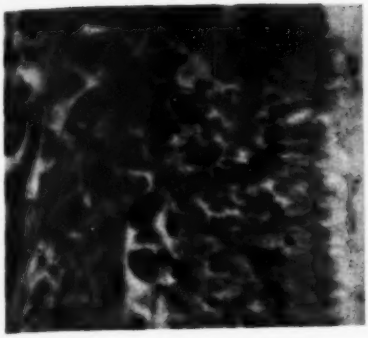

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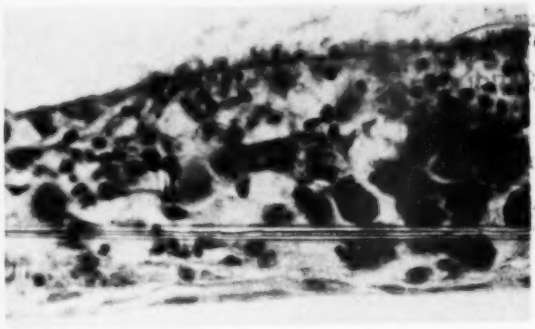

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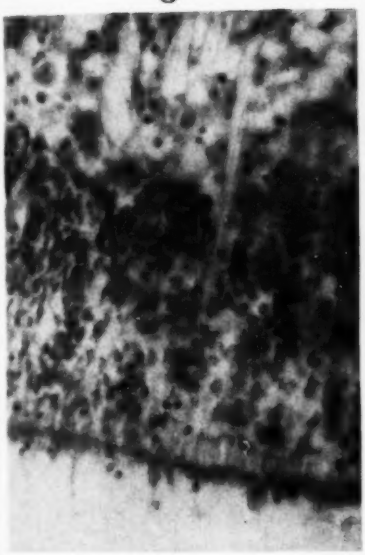

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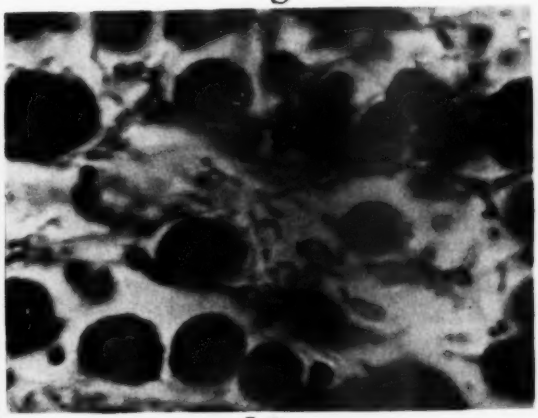

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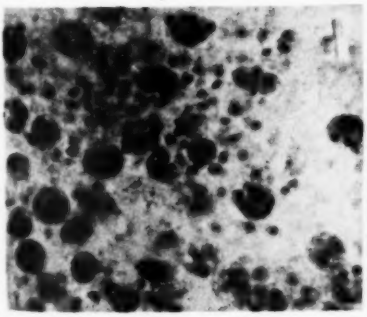

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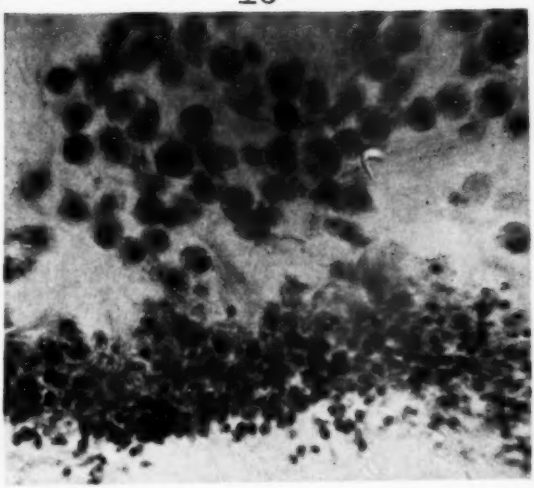

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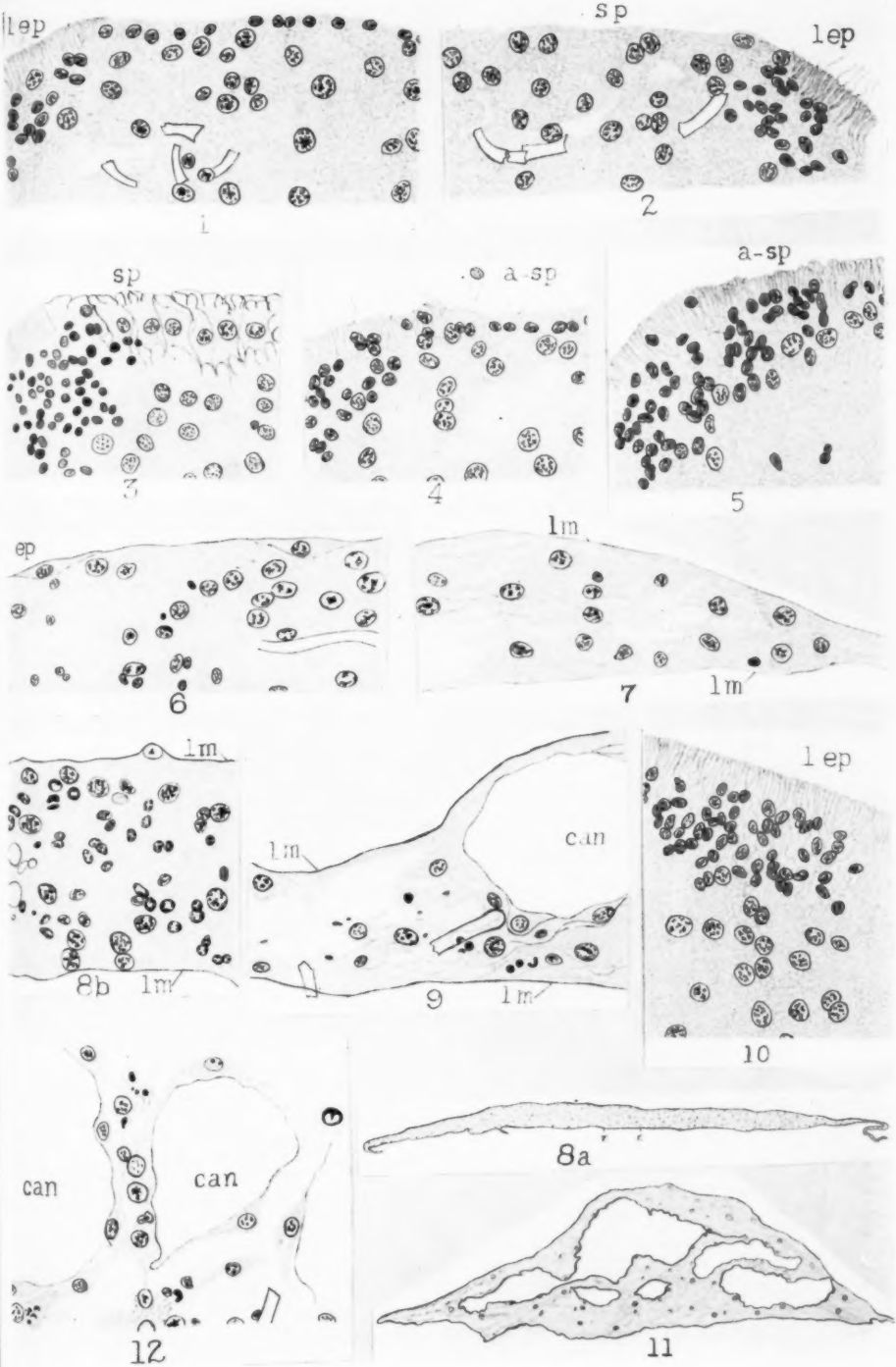
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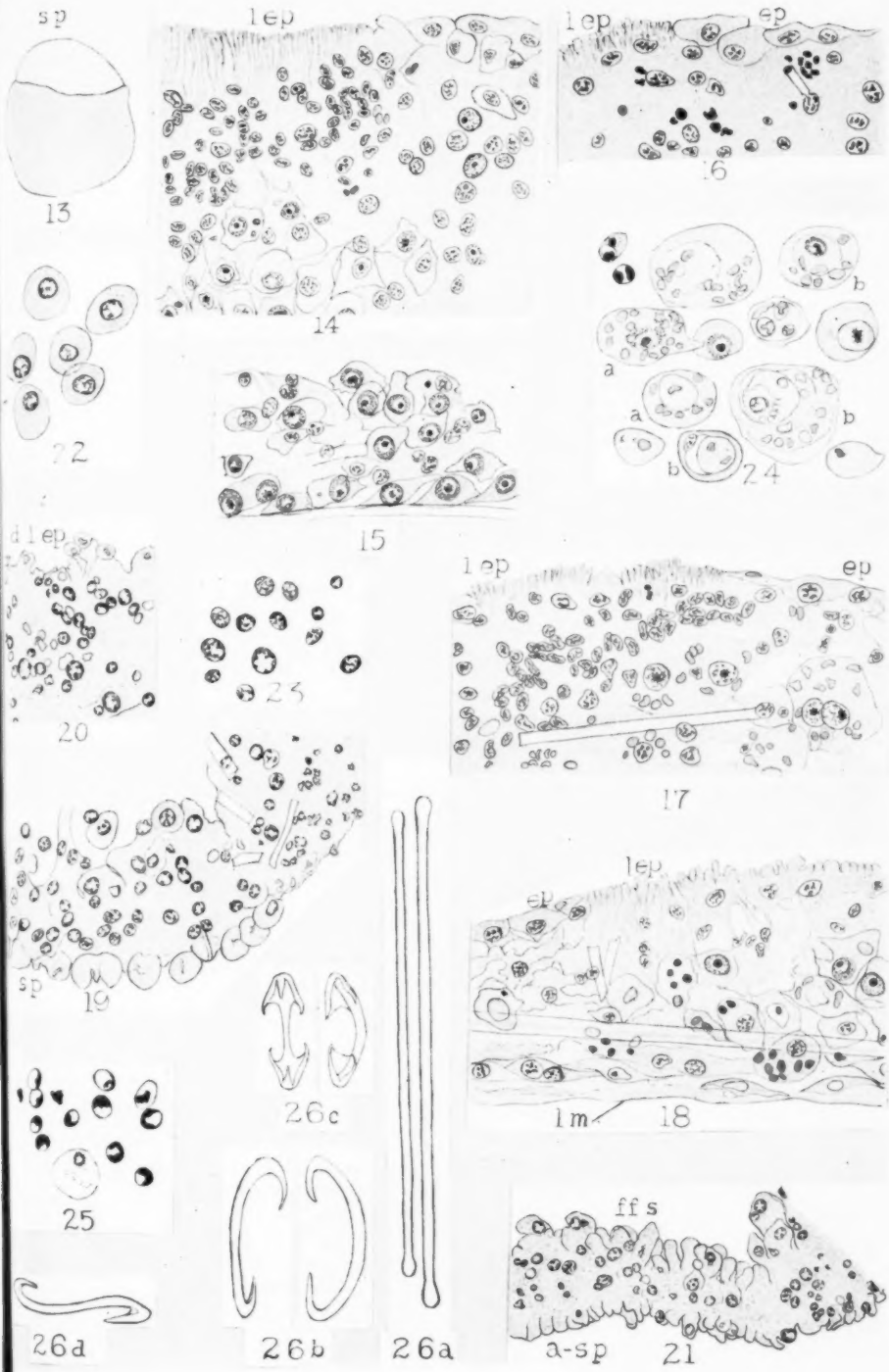
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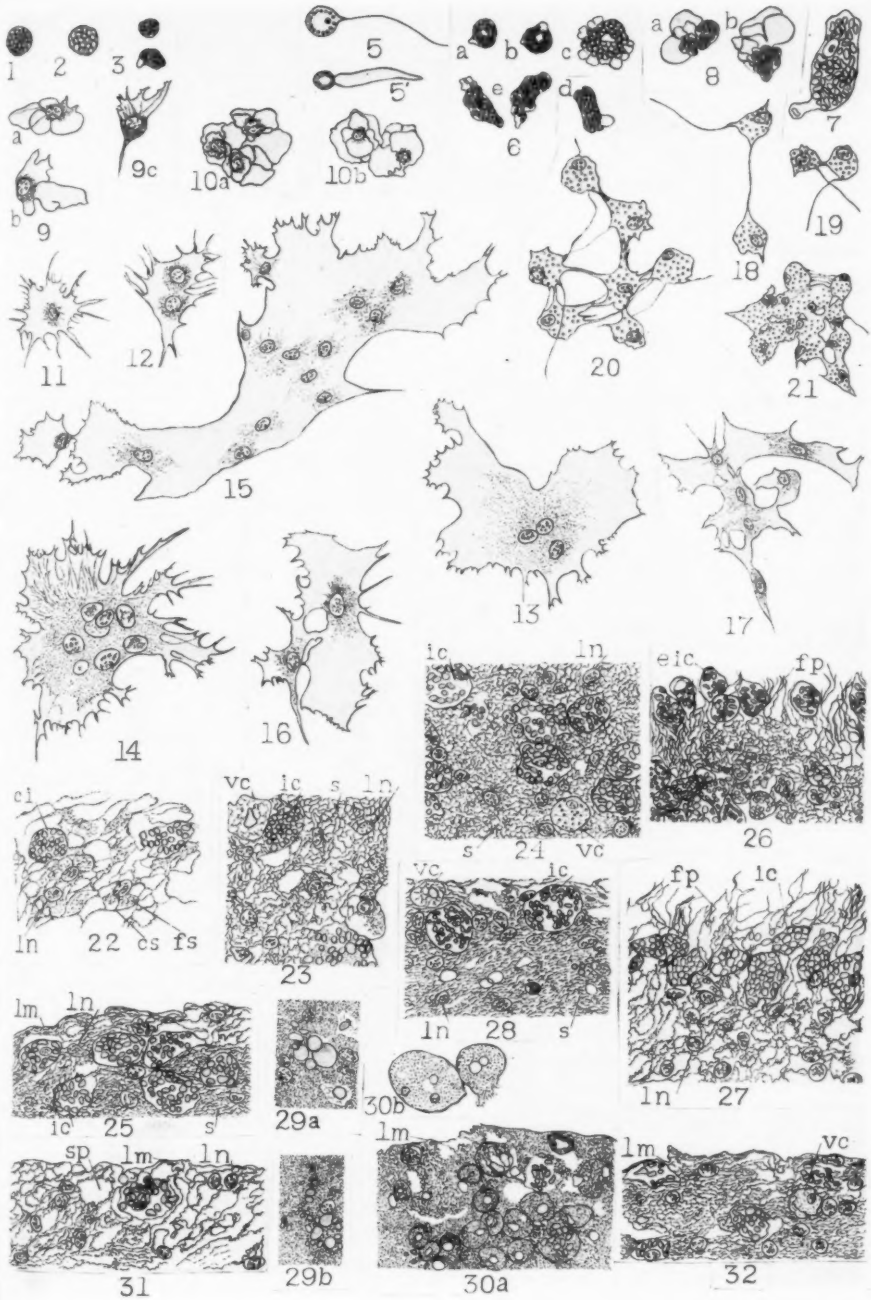
PLATE 60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A SPECTRO-COMPARATOR FOR THE STUDY OF HEMOGLOBIN

By F. G. Hall

Plate 61 and One Text-figure

A method for the spectroscopic study of hemoglobin in dilute solutions was described a year ago (Hall, Jour. Physiol. **80:** 502. 1934). Since that time a few modifications have been made that seem to simplify such a method and increase its accuracy. For these reasons they are now described.

THE MICROSPECTROSCOPIC COMPARATOR

A Zeiss microspectroscopic eyepiece attached to a Hastings pH colorimeter (Bausch and Lomb) is shown in the photograph (pl. 61). The ocular and prisms, as well as the cups and plunger on one side, are removed from the colorimeter. A brass tube in which a 6 volt mazda bulb is held is shown just below the lower cup. Oxygenated hemoglobin is placed in the upper cup and reduced hemoglobin in the lower. A few grains of sodium hydrosulphite are used to keep the hemoglobin fully reduced. The distance between cups is usually kept at 20 millimeters. The Hastings type of colorimeter has been found to be a much more convenient type than that previously employed which had a plunger attached to a movable cup. Its only disadvantage is that it requires a greater quantity of the standard solution. The change in the position of the microspectroscopic eyepiece from the vertical to the horizontal is a decided improvement.

THE WATER BATH

In the previous description of this method, tonometers were removed from a constant temperature bath and placed in a small glass water bath in front of the side opening of the spectroscope. A more satisfactory arrangement has been devised making it unnecessary to remove the tonometer during the course of equilibration and subsequent reading. The accuracy of the method has been increased thereby. The manner of holding tonometers is shown in figure 1. After equilibration a beam of light can be projected through the hemoglobin solution within the

tonometer to the spectro-comparator where comparisons can be made with standard solutions.

A copper jacketed water bath was constructed with a brass collar (*B*) in which a brass holder (*A*) can be rotated. A tonometer is placed into (*A*) and shaken through a 20–30 degree angle from the horizontal plane so that a solution will flow from one end of the tonometer to the other. After ten minutes of shaking the tonometer is brought into a vertical

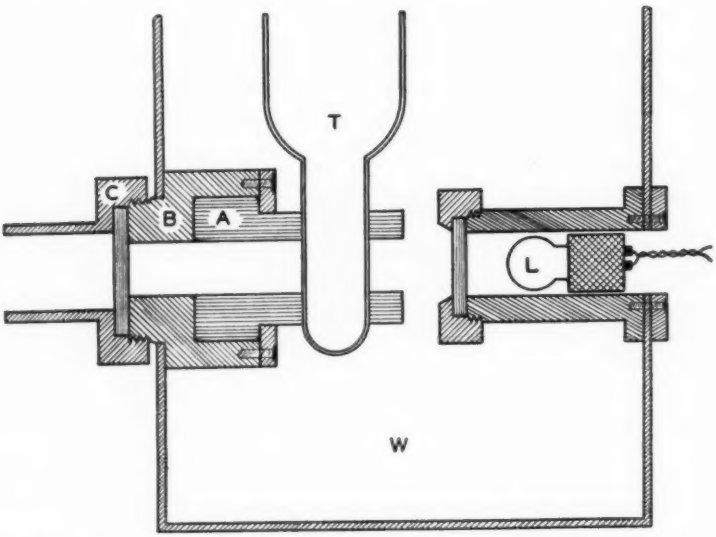

FIG. 1. Shows the position of a tonometer in the water bath (*W*). The holder (*A*) for the tonometer (*T*) rotates in (*B*). Two glass discs are shown, one between (*C*) and (*B*) and one in front of light (*L*).

position and the solution flows into the test-tube like end, through which the beam of light from (*L*) passes. A brass collar (*C*) was constructed to fit into the end of the spectroscopic eyepiece. A glass disc such as is used in colorimeter cups is held between (*C*) and (*B*).

A brass tube (*D*) with a frosted glass disc contains a 6 volt mazda bulb (*L*). The intensity of illumination from (*L*) and from the light on the colorimeter is controlled from resistances near the colorimeters. A resistance box is shown beneath the colorimeter in plate 61.

TONOMETERS

A photograph of a tonometer is shown in plate 61. The end which was inserted into holder (*A*) was similar to a test-tube and about 15 millimeters in diameter. The inside diameter should be known. The aperture in (*A*) and (*B*) through which light passes to the spectro-comparator was 10 millimeters in diameter. Consequently, knowing the inside diameter of the tonometer one can calculate the average depth of solution for an area of cross section of a beam of light of 10 millimeters. This should be taken into consideration in making proper dilution of standards for the colorimeter cups. When that is done the standard solutions will yield a comparable spectrum to that in the tonometer.

TABLE 1

SHOWING A COMPARISON OF SPECTROSCOPIC AND VAN SLYKE ANALYSES ON SHEEP'S HEMOGLOBIN AT VARIOUS OXYGEN TENSIONS IN PHOSPHATE BUFFER, pH 6.8

PARTIAL PRESSURE OF OXYGEN	PERCENTAGE SATURATION WITH OXYGEN	
	Spectroscopic	Van Slyke
mm. Hg		
19	13	14
31	29	31
40	45	43
52	61	59
60	69	67
65	61	60
71	74	72

A total capacity of about 60 cc., when 5 cc. of hemoglobin solution is used, has been found to be a satisfactory one for tonometers.

PROCEDURE

Samples of blood are hemolysed in 10 volumes of distilled water and centrifuged for 2 or 3 minutes. Five cubic centimeters of the hemolysed solution is added to 45 cc. of an appropriate buffer solution. If blood of low oxygen capacity is used it may be necessary to use a smaller dilution. In order to get best results one should attempt to obtain a dilution which will give the most distinct absorption bands.

If the depth of solutions in the colorimeter cups is made equal to the average depth of solution in the tonometer through which the light traverses, the spectra should be identical. A more convenient manner

of reading and simplifying calculations of results is to set the depth of solutions in the colorimeter at 20 millimeters and to further dilute the standards to the extent that their hemoglobin concentration multiplied by 20 is equal to the hemoglobin concentration in the tonometer multiplied by the average depth of the solution (in millimeters), then the two spectra will be identical.

Calculations of oxygen tensions are made as previously described.

The results of a comparison of determinations made on purified hemoglobin with a Van Slyke manometer apparatus and the spectro-comparator are shown in Table 1. Great care was taken to prevent formation of methemoglobin. It will be seen that the spectro-comparator yields results fairly similar to that of the Van Slyke apparatus.

The spectroscopic method is limited to percentage saturations between 20 and 80 and it requires some practice in matching the spectra. Thus there is introduced a subjective error. Its chief advantages are simplicity and economy of samples. It is particularly useful where hemoglobin is to be studied in dilute solutions.

SUMMARY

Improvements on a spectroscopic method are described whereby dissociation curves of hemoglobin can be made.

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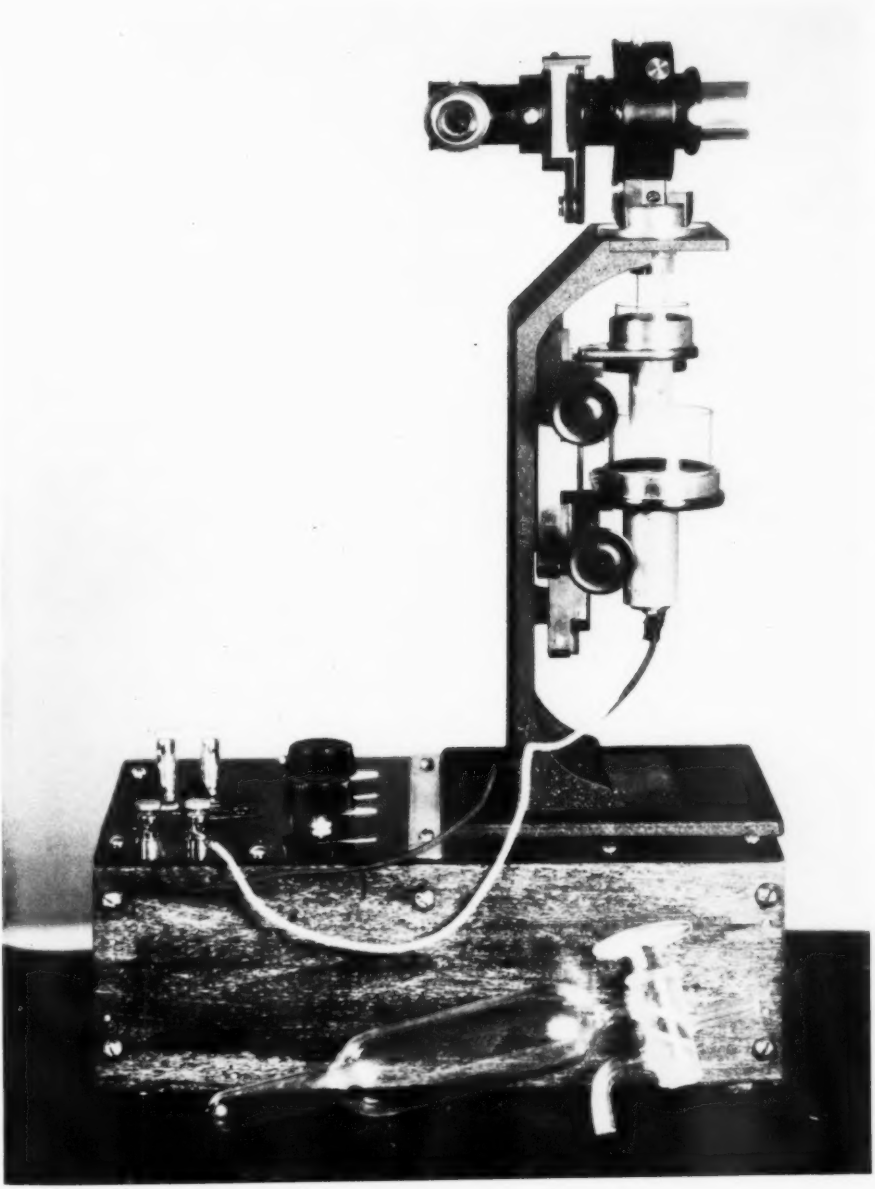
PLATE 61

PHOTOGRAPH OF SPECTRO-COMPARATOR SHOWING POSITION OF THE SPECTROSCOPIC EYEPIECE

A resistance box and tonometer is shown beneath the colorimeter

PLATE 61



AN INCOMPLETELY KNOWN CHYTRID: MITOCHYTRIDIUM RAMOSUM

By JOHN N. COUCH

PLATE 62

The genus *Mitochytridium* was established by Dangeard in 1911 for a Chytridiacean fungus which he found attacking desmids of the species *Docidium Ehrenbergii* and named *M. ramosum*. By the structure and arrangement of the rhizoidal system this parasite showed a resemblance to *Catenaria anguillulae* but differed from that in the absence of cross walls in the part of the thallus which gives rise to spores. There is also a resemblance to *Lagenidium* and *Myzocytium* but these two latter genera lack rhizoids and the thallus, when well developed, is separated into several or many distinct sporangia. Dangeard was of the opinion that this parasite was intermediate between the Chytridiaceae and the Ancylistaceae.

Butler (1928) was of the opinion that the fungus should be put in the Cladochytriaceae close to *Catenaria*. Fitzpatrick (1930) placed the genus in the doubtful or excluded Ancylistales because of Dangeard's rather inadequate discussion of its relationship.

Up to the present time the fungus has not been reported since Dangeard's original description. I found the species growing abundantly May 19, 1933, in *Docidium Ehrenbergii* and other species of desmids collected from near Wilmington, N. C., April 23, 1933. Because of the abundance of material, it was possible to work out most of the details in the life history of the parasite, and since the position of the fungus was doubtful it seemed worthwhile to record these observations. The original description of Dangeard is complete in most details and hence I was able to add but little to his observations. The most important additional observation was that the wall membrane gives a pale purplish color with chloriodide of zinc thus indicating its cellulose composition and its similarity to the cell walls of the Ancylistales rather than to the Chytridiales.

DEVELOPMENT OF THE FUNGUS

A spore of the parasite comes to rest on the host, loses its cilium and sends through the host wall a thin tube. The tube may enlarge into the

thallus of the parasite immediately upon penetration or it may grow for some distance before enlarging. Only in a few cases have I been able to detect the old empty spore membrane. The thallus as a rule becomes detached from the empty spore membrane. The thallus grows, becoming 10–13μ thick and sometimes extending for the entire length of a *Docidium* cell (about 660μ long). Usually, however, the thallus is shorter. Sometimes the individual parasites may be nearly straight and unbranched, more frequently, however, the thallus is twisted and branched. As a rule the fungus is of more or less the same thickness throughout its length though not rarely one notices places in the thallus up to 20μ thick. The rhizoid is usually single, i.e., it extends out from the body of the parasite as a single thread which quickly branches out into a number of fine threads. The rhizoids are fairly conspicuous on young plants but as the plant matures they become more or less empty so that they are rather difficult to see except under high magnification ($\times$1,000 or more).

The protoplasm has the pale whitish gleam and the fat globules characteristic of the Chytridiales. The development of the sporangium appears to be the same as in *Rhizophidium globosum*.

Just before the maturing of the spores a narrow emergence tube grows out through the wall of the desmid (fig. 6) and through this the mature spores are discharged (fig. 9). The spores emerge with their cilia directed backwards and swim away immediately upon reaching the exit. The spores swim as is characteristic for the chytrid spore such as *Rhizophidium*, darting here and there with the cilium behind.

In the same desmid with the sporangia several or many spherical or somewhat elongated thick-walled resting bodies may be formed. These vary from 12–18μ thick. It appears that several resting bodies may be formed from a single spore (fig. 8). During the development of the resting body it is equipped with rhizoids which disappear leaving a few spines or blunt protuberances. Germination of these bodies has not been observed. The fact that they give a cellulose reaction with chloriodide of zinc as do the sporangial walls and are rather constantly associated with the sporangia is good evidence that the resting sporangia belong to the same fungus.

It appears to me that this fungus is closer to the Chytridiales than to the Ancylistales for the following reasons: (1) the presence of rhizoids, and (2) the development, structure, and mode of swimming of the zoospores which are as in typical chytrids. The resemblance to *Lagenidium* in the shape of the thallus (except for the rhizoids in the

present plant) and in the cellulose wall is striking but the characters mentioned above relating the fungus to the Chytridiales would seem to be of more fundamental importance.

This fungus seems to belong in the Cladochytriaceae as already suggested by Butler (1928). It is interesting to note that Dangeard himself considered the fungus a chytrid as his title indicated. The present fungus differs from *Catenaria* in that in the latter the thallus usually becomes segmented into several sporangia connected by narrow isthmuses, whereas in the present fungus the thallus gives rise to only one sporangium. It appears however, that in *Mitochytrium* one thallus may give rise to several resting sporangia (fig. 9). It is true as pointed out by Butler (1928) that in *Catenaria* the thallus may sometimes become a single sporangium.

If the cell wall of *Catenaria* should turn out to be cellulose that would indicate a further relationship between that fungus and *Mitochytridium*.

The present fungus may easily be distinguished from *Endochytrium* or *Megachytrium*, two new genera recently described by Sparrow (1933), since in both of these genera the sporangia open by the pushing aside of a distinct operculum.

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EXPLANATION OF PLATE 62

MITOCHYTRIDIUM RAMOSUM DANGEARD

Fig. 1. Habit of fungus in cell of *Docidium* sp. Also parasitic on the same desmid is a species of *Phlyctochytrium* and *Rhizophidium*. ×262.

Figs. 2–4. Early stages in development of sporangia. Figure 4 shows rhizoids still continuous with sporangium. Figures 2 and 3 ×840, figure 4 ×938.

Figs. 5, 6. Later stages in development of sporangia and spores. Figure 5 shows how the tiny globules of fatty (?) material collect to form a single large globule for each spore. In figure 6 the rhizoids are separated from the sporangia by septa. Figure 5 ×840, figure 6 ×938.

Fig. 7. A small sporangium with infecting cell still evident. ×1120.

Fig. 8. Part of a desmid containing several large sporangia one with spores about ready to emerge and the others with spores emerging.

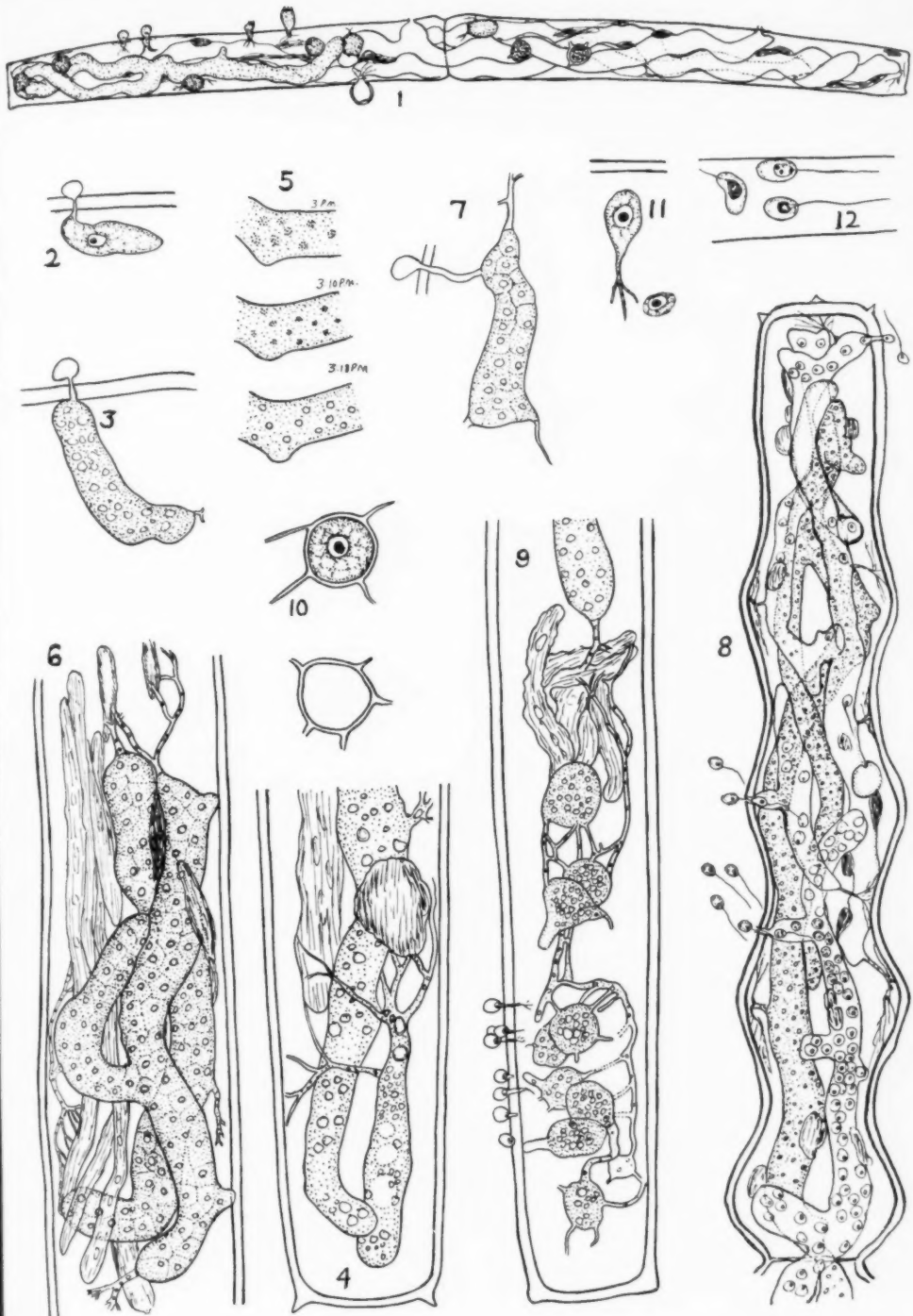
Fig. 9. Several resting bodies connected by narrow threads. As the resting bodies mature these connections are broken. ×840.

Fig. 10. Mature resting bodies, one showing nucleus. ×938.

Fig. 11. Young thalli, one before and the other after rhizoids have begun to develop. ×938.

Fig. 12. Spores killed in sporangium and stained with iron alum haematoxylin, showing cilia and nuclei. ×1425.

PLATE 62.



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A STUDY OF THE CAVE SPIDER, NESTICUS PALLIDUS EMERTON, TO DETERMINE WHETHER IT BREEDS SEASONALLY OR OTHERWISE

By J. D. Ives

The study was made at Three Springs Cave (Buttry's Cave, Delaps Cave), Tennessee. The spiders were studied in a secluded chamber 800 feet from the main entrance. As in the deep interior of other caves, the temperature, relative humidity and light remain practically constant throughout the year. The recorded temperatures range between 58° and 60°F. The relative humidity being above 80 per cent (Jour. of the Elisha Mitchell Sc. Soc., Vol. 43, Nos. 1 and 2, December, 1927, page 86). The evaporating power of the air was only 0.004476 cc. per hour between 4:40 P.M., October 25, 1928, and 6:20 A.M., November 10, 1928.

The animals that have been found in this inner chamber are one salamander, *Gyrinophylus danielsi*, numerous individuals of the milliped, *Cambala annulata* Say, a number of individuals of the rove beetle *Echochara lucifuga* (*Rheochara lucifuga* Casey), a number of individuals of the fungus gnat, Sciara sp. and six specimens of *Prionochaeta opaca* Say (determined by W. S. Fisher of the U. S. National Museum). Mr. Fisher states that this beetle is a normal surface form, living in animal and bird nests. There is a deep sink hole not very far from this region of the cave and probably this beetle obtained entrance through some small passages from there. The beetles were caught in a trap of meat bait and Galt's solution (H. S. Barber, Jour. Elisha Mitchell Sc. Soc., June, 1931, Vol. 46, No. 2, pp. 259–265).

From January, 1933, through September, 1933, a record was made each month of those spiders which were carrying cocoons. The carrying of a cocoon was the criterion used to determine the breeding of the spider, *Nesticus pallidus* Emerton. Some spiders were found which were carrying egg cases all during this period. However during this period a very limited space was observed, but the results were interesting enough to attempt a more extended study to determine if *Nesticus pallidus* Emerton bred seasonally or if it did so more or less throughout the year, since temperature, light and relative humidity remain practically constant, as already indicated. It was therefore decided to study a

larger area. There was included in the larger area a mound of bat guano, 6 or 7 feet in extent and 2 or 3 feet high. The walls of the cave next to the mound were also included but not the top of the chamber which was too high for accurate observation. Each time counts were made they were confined to this area, and were limited to the large adult spiders, though a very few not fully mature spiders may have

TABLE 1

COUNTS MADE OF NESTICUS PALLIDUS EMERTON, WITH A COCOON ATTACHED, WITHOUT A COCOON ATTACHED AND THE TOTAL NUMBER OF SPIDERS COUNTED, AT 800 FEET FROM THE ENTRANCE OF THREE SPRINGS CAVE, 10 MILES FROM MORRISTOWN, TENN.

TIME	SPIDERS WITH COCOONS	SPIDERS WITHOUT COCOONS	TOTAL NUMBER OF SPIDERS COUNTED
1933			
Oct. 12	26	42	68
Nov. 14	19	47	66
Dec. 12	14	47	61
1934			
Jan. 13	24	47	71
Feb. 10	25	61	86
Mar. 14	34	36	70
Apr. 16	45	39	84
May 16	17	56	73
June 18	23	63	86
July 23	12	50	62
Aug. 21	10	60	70
Sept. 18	20	45	65
Oct. 15	50	49	99
Nov. 15	14	62	76
Dec. 14	21	45	66
1935			
Jan. 14	19	47	66
Feb. 13	26	47	73
Mar. 14	28	60	88
Apr. 16	28	54	82

been counted a few times. Only those cocoons were counted that were being carried by the mother spider. The results of the study are given in table 1 and are represented in graphic form by figure 1.

The table and figure show that breeding occurred throughout the year and that there occurred two times of more than usual breeding activity during the period studied. One time of excessive cocoon formation occurred in April and the other in October of 1934. The April large production of cocoons is rather remarkable in that it corre-

sponds very well with the general breeding season outside the cave. A theory as to the excessive breeding periods, as observed in the cave with reference to *Nesticus pallidus* Emerton, was made after a careful study of the notes of the expeditions, but more data are desired and are being collected to test the verity of the theory. However the data already obtained prove that *Nesticus pallidus* Emerton does breed both

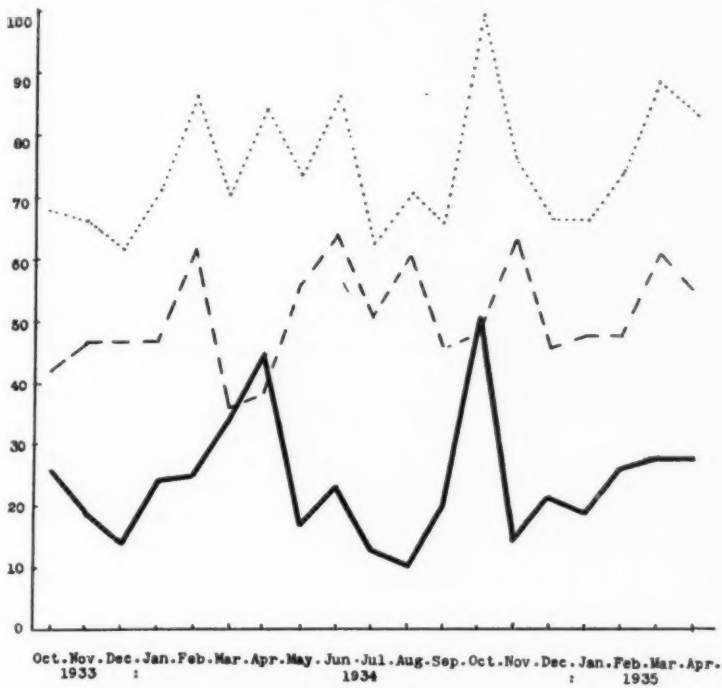

FIG. 1. The ordinates represent the number of spiders observed. The abscissae indicate the date of observation. ——— spiders carrying cocoons. — — — spiders without cocoons. ..... total number of spiders counted.

winter and summer throughout the year as indicated for the period between October 12, 1933, and April 16, 1935, regardless of whether there is a breeding season outside of the cave or not, since at least some spiders were found with cocoons at all times during that period.

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CHANGE OF RESILIENCY WITH THE VELOCITY OF IMPACT

By J. B. Derieux

When a body is suddenly distorted and suddenly released, the average external force exerted by it in returning to its original shape is less than that which is required to distort it. A standard method of demonstrating it, and measuring the relative values, is the method of letting the body fall from a measured height onto a rigid, immovable surface which is horizontal, and observing the height of rebound. The height of rebound is always less than the height of fall. If the forces were equal, the heights would be equal.

The velocity of impact and the velocity of rebound can be computed from their respective heights. The ratio of the latter, or restored velocity, to the former, or destroyed velocity, is called the Coefficient of Restitution, i.e., its value is the coefficient by which the destroyed velocity must be multiplied to find the restored velocity. Expressed in mathematical terms,

$$k = v_1/v, \text{ or } v_1 = kv,$$

where v and v_1 are the velocity of impact and velocity, of rebound respectively, and k is the coefficient.

The ratio of the total change in velocity, including sign, to the velocity of impact is called the Resiliency. Mathematically, again,

$$R = (v + v_1)/v, \text{ or } R = 1 + v_1/v = 1 + k.$$

Therefore, in determining the resiliency of a body the method is to measure its coefficient of restitution, and add unity to it.

The published values of the Resiliency of bodies give only one value for each, thus indicating that it is a constant. I had suspected that it might not be constant, but might vary with the velocity of impact, and, hence, the present problem was undertaken. Golf balls were selected as suitable bodies with which to make the study. The range in velocities was obtained by dropping them, in addition to the usual laboratory height, from the first, second, and third floors and the roof of the physics building of State College onto the stone steps. The heights of rebound were determined by an observer stationed on a slight elevation at a little

distance from the building, and who noted the points on the building to which the balls rebounded.

As previously indicated, the Coefficient of Restitution was first computed, and then the Resiliency was taken as that plus unity. It was realized that the resistance of the air had a considerable effect on the high velocities used, and, therefore, the velocities were computed by the following line of reasoning. *Considering first that of the Fall,* the kinetic energy at impact must equal the work of gravity during the fall, diminished by the work of the resistance of the air. Or

$$wv^2/2g = wh - W_r,$$

where w is the weight of the ball, v, its velocity at impact, g, the acceleration of gravity, and W_r is the work of the air resistance. Solving,

$$v = \sqrt{2gh - 2W_r g/w} \tag{1}$$

For the work of the air resistance,

$$W_r = \int_0^h r\,dy \tag{2}$$

Here r is the resistance, dy, the increment of fall, and h is the total height of fall. Substituting the value of the resistance, obtained from a previous piece of research which I had done,

$$W_r = 2.62 \times 10^{-5} \int_0^h v^{1.63}\,dy \tag{3}$$

To convert to a single variable, use was made of the simple vacuum relation,

$$v = (2gy)^{\frac{1}{2}},$$

which, while it is only approximately correct due to the air resistance, is only a correction term, and gives a maximum error of less than 1 per cent in the final result, for the values of v which I used, which is as close as I claim for my observations. The exact method, which is far more complicated, leading into an infinite series, but which must be used with higher velocities or for closer accuracy, will be given at the close of the paper. Substituting in (3),

$$W_r = 2.62 \times 10^{-5} \int_0^h (2gy)^{.82}\,dy = 2.62 \times 10^{-5} \times \frac{(2gh)^{1.82}}{1.82 \times 2g}.$$

Substituting in (1),

$$v = \sqrt{2gh - \frac{2.62 \times 10^{-5} (2gh)^{1.82}}{1.82\, w}}\,.$$

Substituting the values of g and w,

$$v = \sqrt{2gh}\,\sqrt{1 - \frac{2.62 \times 10^{-5} (64.4)^{.82}}{1.82 \times 0.1}\, h^{.82}}\,.$$

Finally,

$$v = \sqrt{2gh}\,\sqrt{1 - 4.35 \times 10^{-3}\, h^{.82}}\,.$$

The $\sqrt{2gh}$ is the usual expression for the velocity of fall where there is no resistance, which, if you please, I should like to call the apparent velocity, and the other radical, I should like to call the correction factor.

The preceding expression, as I mentioned, is for the velocity of Fall. In *the Rebound*, the resistance of the air aids gravity, and the initial expression is

$$wv_1^2/2g = wh_1 + W_r\,.$$

The final result for it is

$$v_1 = \sqrt{2gh}\,\sqrt{1 + 4.35 \times 10^{-3}\, h_1^{.82}}\,.$$

The Coefficient of Restitution,

$$k = v_1/v = \frac{\sqrt{2gh_1}\,\sqrt{1 + 4.35 \times 10^{-3}\, h_1^{.82}}}{\sqrt{2gh}\,\sqrt{1 - 4.35 \times 10^{-3}\, h^{.82}}}\,.$$

The ratio of the first two radicals reduces to $\sqrt{h_1/h}$, which is the usual form without resistance, and which I shall call the apparent coefficient and, therefore, I shall call the ratio of the second two radicals the correction factor.

You can see from the values in the table that my suspicion as to the lack of constancy of the coefficient of restitution and of the resiliency, as the velocity changes, is rewarded. The former shows a decrease of 5.5 per cent, and the latter a decrease of 2.5 per cent as the velocity increases, in the small range which I used. Therefore, as a means of standardizing, I suggest that when the value of the coefficient of restitution or the resiliency for a body of material be given, that it be the value for zero

velocity, as is similarly done for other phenomena which vary with their conditions. This reduction to zero value may be made by formula or graph as described in my next paragraph.

The graph obtained of the Coefficient of Restitution against velocity is a nice smooth curve. To determine how the coefficient changes in

TABLE 1

HEIGHT		APPARENT VELOCITY		VELOCITY CORRECTION FACTOR		CORRECTED VELOCITY		APPARENT COEFFICIENT	COEFFICIENT CORRECTION FACTOR	CORRECTED COEFFICIENT OF RESTITUTION	RESILIENCY
Fall	Rise	Impact	Rebound	Impact	Rebound	Impact	Rebound				
ft.	*ft.*	*ft./sec.*	*ft./sec.*			*ft./sec.*	*ft./sec.*				
0.0*	0.0	0.0	0.0	1.00	1.000	0.0	0.0	.836	1.00	.836	1.836
3.00	2.05	13.9	11.5	.995	1.004	13.8	11.55	.826	1.009	.835	1.835
16.33	10.30	32.4	25.7	.978	1.013	31.7	26.00	.794	1.038	.824	1.824
29.00	17.00	43.3	33.1	.965	1.023	41.8	33.98	.767	1.062	.814	1.814
47.50	25.58	55.3	40.6	.947	1.032	52.3	42.01	.734	1.091	.800	1.800
60.00	30.70	62.2	44.5	.935	1.036	58.1	46.1	.715	1.107	.790	1.790

* This line of data was determined from a graph, as described in the paper.

relation to the velocity, an exponential relation was assumed and the equation

$$k = c - c_1 v^n$$

solved by substituting values of k and of v from the data. The solution is

$$k = .836 - 5.71 \times 10^{-6} v^{2.21}.$$

A graph between coefficient and (velocity)$^{2.21}$ is linear, thus verifying the solution. After getting the linear graph, its prolongation until it cuts the axis of coefficients gives, of course, the value of the coefficient for zero velocity, which is .836. The general equation is

$$k_v = k_o - 5.71 \times 10^{-6} v^{2.21},$$

or

$$k_o = k_v + 5.71 \times 10^{-6} v^{2.21},$$

where k_v and k_o are the coefficients at velocities v and o, respectively. The latter form serves for finding the value at zero velocity. For the equation of Resiliency, adding unity to the coefficient,

$$k_v + 1 = k_o + 1 - 5.71 \times 10^{-6} v^{2.21},$$

or

$$R_v = R_o - 5.71 \times 10^{-6} v^{2.21},$$

and

$$R_o = R_v + 5.71 \times 10^{-6} v^{2.21},$$

where R_v and R_o are the resiliences for velocities v and o, respectively.

Several other interesting graphs and relations were obtained from the results. Taking them in the order in which they appear in the table, there are two for the Velocity Correction Factors, as ordinates, in relation to Height. The graph for the fall is inclined downward but is concave upward, while the one for the rebound rises but is convex upward. The equations for them are

$$Cf = \sqrt{1 - 4.35 \times 10^{-3} h^{.82}},$$

and

$$Cr = \sqrt{1 + 4.35 \times 10^{-3} h^{.82}},$$

respectively, as is shown in the previous method of analysis. Then there is one for the Initial Velocity of recession, and Height of Rebound as abscissa. The graph rises and is convex upward. The equation is

$$v_i = \sqrt{2gh}\ \sqrt{1 - 4.35 \times 10^{-3} h^{.82}}.$$

The graph for the Final Velocity, and Height of Fall as abscissa, rises but is convex upward, and more convex than the one for rebound. It was extended by the infinite series method mentioned previously, and given later, and the velocity was found to reach its maximum value of 158 feet per second in a fall of about 2000 feet, the graph becoming horizontal.[1] An application of this to the case of a golf ball dropped from an aeroplane is interesting. When first dropped, its velocity would increase at the rate of 32.2 feet per second, but this rate would decrease, due to the resistance of the air, and when it had fallen about 2000 feet its velocity would be constant, at 158 feet per second. Another graph and relation is the Height of Fall, abscissa, against Restitu-

[1] See page 207 of this issue.

tion Correction Factor. This rises and is convex upward. The equation for it is

$$Cf = 1.00 + 4.67 \times 10^{-3} h^{.77}.$$

Now, for the more exact equation of motion. For unit of mass,

$$dv/dt = g - cv^n,$$

where g is the acceleration of gravity, c is a constant, v, the velocity, and n the exponential rate of change of resistance with velocity. If V represent the limiting velocity attainable in falling, due to resistance, then

$$0 = g - cV^n \quad \text{or} \quad c = g/V^n.$$

Substituting,

$$\frac{dv}{dt} = g - g\frac{v^n}{V^n} \quad \text{or} \quad \frac{vdv}{dh} = g\left(1 - \frac{v^n}{V^n}\right),$$

whence

$$gdh = \frac{vdv}{1 - \frac{v^n}{V^n}} = v\left[1 - \left(\frac{v}{V}\right)^n + \left(\frac{v}{V}\right)^{2n} + \cdots\right]$$

Integrating,

$$gh + C = v^2\left[\frac{1}{2} - \frac{1}{n+2}\left(\frac{v}{V}\right)^n + \frac{1}{2n+2}\left(\frac{v}{V}\right)^{2n} + \cdots\right]$$

If the body falls from rest, $h = 0$ when $v = 0$, and, therefore, $C = 0$. By substituting a series of values for v, V having previously been determined to be 158 feet per second, and solving for h in each case, a series of values of h was determined from which a graph between h and v was plotted, and from it the value of v corresponding to any h was read.

For the Rebound, the initial equation is changed only by a plus sign in the last term, because gravity and resistance then operate in the same direction. This sign change results in changing the final form only by a negative sign before the even numbered terms of the bracket.

STATE COLLEGE,
RALEIGH, N. C.

NOTES ON SOME OOMYCETES FROM THE VICINITY OF MOUNTAIN LAKE, GILES COUNTY, VIRGINIA[1]

By VELMA D. MATTHEWS

PLATE 63

Although some work has been done on the oomycetes of Virginia, published records on the distribution of members of the families Saprolegniaceae, Ancylistaceae, Leptomitaceae, and Monoblepharidaceae seem to be practically lacking, so far as the writer is aware. Coker (1927) lists *Achlya flagellata* and a sterile form of *Saprolegnia* from Charlottesville, Virginia. Drechsler (1927) reports *Plectospira myriandra* from Rosslyn, Virginia, and the same author (1935) isolated *Aphanomyces cladogamus* from this state. Couch (1935) described *Lagenidium giganteum* from Mountain Lake, Virginia, and Chapel Hill, N. C. During July and August of 1935 the writer noted the occurrence of several genera belonging to the above mentioned families in about sixty collections of water, twigs that had been lying in the water for some time, and soil. These collections were made within three miles of the Mountain Lake Biological Station at elevations ranging from about 3,800 to 4,300 feet. All of the species listed below except two, although they are probably very common in many parts of the state, are reported from Virginia for the first time and a few of them have not previously been reported from the south.

SAPROLEGNIACEAE

Saprolegnia diclina Humphrey, Trans. Am. Phil. Soc. **17**: 109, pl. 17, figs. 50–53. 1892 (1893).

Growing on a clump of salamander eggs on damp moss. Also very abundant in the water of the lake.

[1] It is a pleasure to acknowledge the many courtesies extended to the writer by Dr. Ivey Lewis, Director of the Mountain Lake Biological Station. The writer is also grateful to Dr. W. C. Coker for suggestions and the use of the University of North Carolina library.

Saprolegnia litoralis Coker, The Saprolegniaceae, p. 54, pls. 15, 16. 1923.

Isolated from a small pool of water containing several species of algae, mosquito larvae, and rotifers in a large rock on the top of Bald Knob at an elevation of about 4,300 feet. All previous collections of this species in the United States have been from the coastal plain of North Carolina.

Isoachlya eccentrica Coker, The Saprolegniaceae, p. 87, pl. 24. 1923.

Isolated twice from soil and once from water: dark sandy soil near *Kalmia* on the grounds of the Biological Station; sandy soil along the path around the lake; collection of water and insect larvae from a small pool in the West Virginia road. Antheridia were lacking in all the collections, but in one collection from soil several sporangia were noted where internal proliferation of sporangia was present. Coker (1923) says that proliferation of sporangia is "never internal as in *Saprolegnia*." Otherwise these cultures agreed with the original description of the species.

Isoachlya unispora Coker and Couch, The Saprolegniaceae, p. 85, pls. 22, 23. 1923.

Isolated once from dark damp soil near Mud Branch on the Biological Station grounds. Previously reported only from water in the type locality, Chapel Hill, North Carolina.

Achlya conspicua Coker, The Saprolegniaceae, p. 131, pls. 45, 46. 1923.

Isolated from a collection of water from the lake containing water mosses and *Isoetes* and from a collection of dark sandy soil near the Biological Station.

Achlya glomerata Coker, Mycologia **4**: 325, pl. 79. 1912.

Isolated from dark wet soil near *Trautvetteria* and ferns in a low place near the Biological Station. In old cultures a few of the eggs germinated by the formation of a short tube at the tip of which a small sporangium was formed.

Achlya imperfecta Coker, The Saprolegniaceae, p. 118, pls. 38, 39. 1923.

Isolated from light gravelly soil in the path around the lake.

Achlya flagellata Coker, The Saprolegniaceae, p. 116, pl. 37. 1923.

Growing on an insect larva in a small pool in the West Virginia road. This species was not found in any of the soil collections. In the piedmont section of North Carolina it is found in the soil more often than any other species of the family. The hyphae of the original collection were heavily parasitized by *Pseudolpidium fusiforme* (Cornu) A. Fischer (see fig. 4) and *Olpidiopsis minor* A. Fischer (see fig. 5). The very large sporangia and resting bodies of *P. fusiforme* caused great enlargements of the host hyphae.

Aplanes Treleaseanus (Humphrey) Coker, Journ. Eli. Mitch. Sci. Soc. **42**: 217, pls. 34, 35. 1927.

Isolated from black damp soil mixed with many hemlock needles from the base of a large hemlock (*T. canadensis*) near the lake. In one culture about three weeks old there were about a hundred typical *Aplanes* sporangia. This collection agreed with the plants obtained by the writer from soil at Lakeview, N. C. (see Coker, 1927).

Thraustotheca clavata (de Bary) Humphrey, Trans. Amer. Phil. Soc. **17**: 131. 1892 (1893).

Isolated from damp coarse sand near the lake.

Leptolegnia eccentrica Coker and Matthews, Journ. Eli. Mitch. Sci. Soc. **42**: 215, pl. 33. 1927.

Isolated 13 times from 39 collections of soil. This was the only fungus obtained from collections of soil made in the typical chaparral formation in the vicinity of Bear Cliff at an elevation of about 4,200 feet. Numerous oogonia with mature eggs were formed in cultures on hemp seed that were left in the soil covered with water for a week or more. Cultures on hemp seed in water formed many spores but only a small number of oogonia developed and few of these matured their eggs. This was the most common species of water mold found in the soil in the vicinity of Mountain Lake. Previously this species has been reported only from the type locality, Chapel Hill, North Carolina.

Dictyuchus monosporus Leitgeb, Pringsh. Jahrb. wiss. Bot. **7**: 357, pl. 22, figs. 1–12 and pl. 23, figs. 1–8. 1870.

Sterile forms were very abundant on many kinds of twigs lying in the lake and in the water of the lake.

Aphanomyces sp.

Growing on a mass of frog eggs in the lake. No oogonia were formed so the species was not determined.

LEPTOMITACEAE

Gonapodya polymorpha Thaxter, Bot. Gaz. **20**: 481, pl. 31, figs. 11–16. 1895.

Growing attached to birch twigs and inside old hyphae of *Dictyuchus*, which were attached to birch twigs that had been lying in the lake. This species was also found on twigs placed in a wire trap in a spring at Chapel Hill, North Carolina, in 1933. Previously not reported south of New York

Sapromyces Reinschii (Schroeter) Fritsch (?), Osterr. Bot. Zeitschr. **43**: 420. 1893.

Growing attached to hemlock, birch, and Rhododendron twigs that were lying in the lake. Sporangia borne in clusters of two to twelve. Oogonia lacking.

MONOBLEPHARIDACEAE

Monoblepharis polymorpha Cornu, Bull. Soc. Bot. France **18**: 59. 1871; Ann. Sci. Nat. 5 th. ser. **15**: 82, pl. 2, f. 1–9. 1872; in Van Tieghem's 'Traité de Botanique' (1874 ed.), fig. 167 B, 4 and fig. 167 C, 7, 1, m, n and 9.

Growing attached to birch twigs lying in the lake. Very rare during July and August but perhaps more abundant in the fall and winter. Previously not reported south of New York.

ANCYLISTACEAE

Lagenidium giganteum Couch, Mycologia **27**: 376, figs. 1–19. 1935.

Growing on a mosquito larva in a small pool in a depression of a large rock on the top of Bald Knob at an elevation of about 4,300 feet. Sexual reproduction lacking.

COKER COLLEGE,
HARTSVILLE, SOUTH CAROLINA.

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PLATE 63

GONAPODYA POLYMORPHA

Fig. 1. Mycelium of fungus forming sporangia inside old hypha of *Dictyuchus* and extending out into the water. ×527.
Fig. 2. Proliferation of sporangia. ×527.
Fig. 3. Zoospore. ×527.

PSEUDOLPIDIUM FUSIFORME

Fig. 4. Resting spores inside hypha of *Achlya flagellata*. ×120.

OLPIDIOPSIS MINOR

Fig. 5. Empty sporangia and resting spores inside hypha of *Achlya flagellata*. ×120.

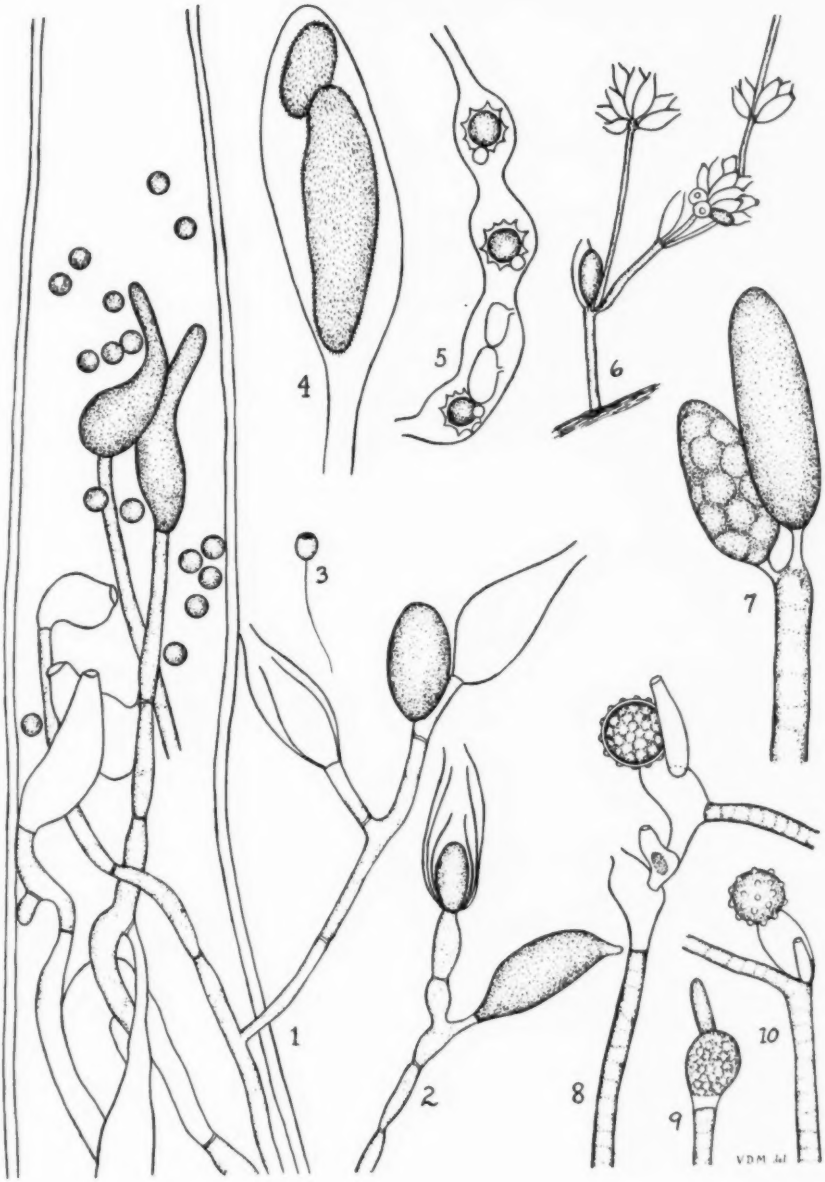
SAPROMYCES REINSCHII

Fig. 6. Plant attached to hemlock twig showing habit of growth. ×120.
Fig. 7. Young sporangia, one showing spore initials. ×527.

MONOBLEPHARIS POLYMORPHA

Fig. 8. Hypha with antheridia and oogonia. ×527.
Fig. 9. Young oogonium with an antheridium. ×527.
Fig. 10. Surface view of oospore after emergence from the oogonium. ×527.

PLATE 63



BASKING SHARK (CETORHINUS MAXIMUS) IN NORTH CAROLINA WATERS

By H. H. Brimley

On February 12, 1935, a female specimen of Basking Shark (*Cetorhinus maximus*) was taken in a shad net about two miles outside Corncake Inlet, this being a small channel connecting the Cape Fear River with the ocean a few miles below Fort Fisher.

The specimen measured 13 feet, 5 inches from tip of snout to tip of tail, with a maximum body circumference of 53 inches, and its weight was about six hundred pounds. The gape was 18 inches in width and the caudal fin measured 41 inches from tip to tip.

One of the most striking features of this species of shark is the enormous size of the gill openings, which very nearly meet on both the upper and under sides of the head.

The liver of our specimen measured 61 inches in length and weighed 65 pounds—mostly oil!

The teeth are numerous, recurved, and very small, with no cutting edges, the exposed part of the longest tooth being only about one sixteenth of an inch in length. The gill-rakers are highly developed and are used much as are the whalebone plates in the baleen whales, for straining from the water that flows into the mouth the small forms of marine life on which the animal feeds.

The Basking Shark is an inhabitant of northern seas, and I know of no specimen having been previously taken south of Sea Girt, New Jersey, which is about 430 miles to the north of Corncake Inlet.

The Museum received the specimen in the flesh and, from copious notes, measurements, sketches and plaster moulds, it is intended to later on reproduce the animal as a life-sized model for exhibition.

State Museum,
Raleigh, N. C.

THE BIRDS OF CHAPEL HILL, NORTH CAROLINA

By Eugene Odum, Edmund Taylor, Coit Coker and Arnold Breckenridge

Plate 64

For the past six years we have been greatly interested in the scientific study of the ornithology of the Chapel Hill region, spending considerable time the year round in field work. Associated with us from time to time have been a number of other bird students who have not only contributed many data but have helped to make the study of birds a real pleasure. We wish to mention in this connection the following: Elmer Brown, Freemont Shepherd, Henry Rankin, Claude Rankin, Nelson Hairston, Jim Stephens, Joe Jones, and Gilbert Wagstaff.

We realize that six years is a rather short period in which to make a reasonably complete local list, but we have amassed considerable material which, together with observations of previous students, badly needs consolidation. Also, because of the increasing interest in birds which has been manifested in Chapel Hill in the last few years, we feel that such a publication as this may be helpful to the many bird lovers as well as form a working foundation for future investigations.

Review of ornithological work. George F. Atkinson (1854–1918), assistant professor in the "Department of Geology and Natural History" here at the University from 1885 to 1888, was the first to make a scientific study of birds at Chapel Hill. However, he was not primarily interested in local birds but in the distribution of North Carolina birds in general, about which there was little known at the time. In 1887 he published "A Preliminary Catalogue of the Birds of North Carolina, with Notes on Some of the Species" (Jour. E. Mitch. Sci. Soc., IV–2, pp. 44–87). In the introduction to this paper he states that he collected specimens at Chapel Hill from January, 1886, to the time of writing except for the fall and summer of 1886. He further states that 120 species were positively identified, 112 of which were preserved, but he fails to list them.

In 1899, T. Gilbert Pearson (now president emeritus of the National Association of Audubon Societies) compiled "A Preliminary Catalogue of the Birds of Chapel Hill, with Brief Notes on Some of the Species" (Jour. E. Mitch. Sci. Soc., XVI–1, pp. 33–51) embodying the results of

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two years (exclusive of summers) of his own studies and the data recorded by Professor Atkinson. He obtained this latter, he states, from a newspaper clipping, "Preliminary List of Birds Collected at Chapel Hill," by Professor Atkinson presumably published about the same time as his North Carolina list. Dr. Pearson's list contains 134 species, 119 of which came under his own observation.

Mr. C. S. Brimley of Raleigh has kindly sent us some scattered notes taken by Mr. G. S. MacNider at Chapel Hill, 1889–1902, which contain authentic records of two additional species, the Wood Ibis and Canada Goose, bringing the total to 136 species.

Alexander Feild in 1912 published a list entitled "Notes on the Birds of Chapel Hill with Particular Reference to their Migration" (Jour. E. Mitch. Sci. Soc., XXVIII–1, pp. 16–33). He lists with notes and some migration data 107 species observed during his four undergraduate years (exclusive of summers). Six species are recorded for the first time, bringing the total recorded number of species to 142.

Aside from these early observers there has been little interest in and very little recorded about local avifauna up until the beginning of our work. The occurrence of only three additional species comes to light, as far as we can determine, two of these being early records apparently not known to Pearson and Feild. These are: Passenger Pigeon (now extinct), one shot in 1887 by Kemp Battle, Jr., Barn Owl taken by T. E. Hester in 1909, and Evening Grosbeak, taken by W. C. Coker in 1922. Thus, at the beginning of our work the "list" was still in an embryonic state totaling 145 species.

Just when our observations began would be hard to say; we have more or less grown up with bird study. Individually we began keeping records about 1928. In 1931 we organized a club and conducted work on a more intensive and concerted scale. Coker and Odum conducted a bird column in the Chapel Hill *Weekly* during 1931 for the purpose of popularizing and stimulating bird study. Detailed records for all seasons have been kept during the four years 1931–34. The greater part of our work has been based on the observation of the living bird in the field, emphasizing occurrence, distribution, and migration; but we have taken for purposes of identification a number of rarer and difficult species. Taylor and Breckenridge have built up small but excellent private collections of bird skins, and we have added some to the University collection. Care and accuracy have been stressed in all field observations. During our study 50 species have been recorded for the first time, making a total of 195 species now known from Chapel

Hill. Many additional data have been added for species already on record. A total of 188 species have actually come under our observation.

The field. The territory covered by this list is included within a six-mile radius of the town. It covers, then, the extreme southeast corner of Orange County, a small section of Durham County west to New Hope Creek, and a small area of Chatham County to the south. This area which we shall simply call Chapel Hill has an average elevation of about 500 feet and is located on the eastern edge of the piedmont region of the state in the Upper Austral or Carolinian life zone. Just a few miles to the east, however, at Raleigh, the Lower Austral zone begins to appear. Therefore, birds generally restricted to that region (i.e., the Chuck-will's-widow and the Prothonotary Warbler) might be expected to occur at Chapel Hill at least rarely.

The region is not extensively cultivated and is well-wooded, well-watered, and rather hilly. Much of the natural forest is made up of deciduous trees of the oak-hickory-maple-dogwood association; there are, however, many pure pine stands, and a great deal of mixed wood containing both evergreen and broad-leaved trees. One or two fairly extensive swampy or marshy lowgrounds exist on Bowlin's and New Hope creeks, but no extensive swamps or open marsh lands and no natural ponds of any size are present. Three creeks, Bowlin's, Morgan's, and New Hope, fed by numerous small streams, flow through the Chapel Hill vicinity in a general southeast direction to unite eventually and form a branch of the Cape Fear river.

Ornithologically speaking, Chapel Hill has remained thus from the beginning of bird study until the present time, except for one important change. The construction of two dams in 1932 to form the extensive University Lake just east of town and the much smaller Hogan's Pond to the north, has provided large bodies of water heretofore lacking. Consequently water birds of many species which were previously unknown or were very rarely known to visit our vicinity now are attracted. The status of many, however, is subject to change because of the instability of the lake biologically.

A mention of a few of the places which we have found richest in bird life and which we have most frequently visited should be of interest to future students. Foremost is the strip of remarkably diversified country, known locally as Strowd's lowgrounds, stretching along Bowlin's Creek east of the Durham highway. There is always something interesting to see here even when things are dull elsewhere. The lake and pond mentioned above, together with the surrounding woods and fields,

are, of course, excellent field localities. Morgan's Creek as well as the portion of Bowlin's Creek west of the Durham highway are good, especially in winter and spring. The New Hope swamp off the Raleigh road seems to be very good for spring transient warblers and for some of the wilder birds. The University-owned woods south of the campus and Battle Park are excellent for fall warblers.

Short review of the seasons; winter. Birds are by no means scarce in winter at Chapel Hill. In fact, one is likely to see more individual birds on a winter's hike than on one in summer and perhaps as many species, because of the flocking tendencies of birds in winter and because of the great abundance of wintering native sparrows of several species. The seven "Christmas censuses" taken by us and published in *Bird-Lore* magazine from 1928 through 1934 give a pretty good cross-section of the winter bird life. These censuses, which are one day lists, range as follows: 1928, 46 species; 1929, 37 species; 1930, 47 species; 1931, 54 species; 1932, 63 species; 1933, 75 species; and 1934, 68 species; the number of individuals ranging between one thousand and three thousand. The great difference in the number of species does not mean that birds were more abundant in latter years, but simply that we have come to know the country better and know where to locate the less common birds. However, the presence of the lake helped greatly in increasing the list for the past three years. Close to 100 species, exclusive of early and late migrants, have been recorded by us during the winter. Of these we can conservatively state that about 60 are of regular occurrence; that is, if one knows where to look for them he stands a very good chance of finding any or all of about that many on a given day. The occurrence of other species is not so certain; they may be present some years, absent others, or at one time during the winter and not at another; one may be able to find them, but cannot depend on it. Some other species are rare with but one or two winter records.

As to the relative abundance of the commonest winter species the following statistics from the seven censuses is interesting though not conclusive: The White-throated Sparrow and the Slate-colored Junco or Snowbird, polling about the same number of individuals, are easily the most abundant. The White-throat is perhaps the more widely distributed. Red-winged Blackbird (local, but large flocks), Song Sparrow, Goldfinch, Swamp Sparrow, Cardinal, Bluebird, and Field Sparrow follow in respective order. Except for the Red-winged Blackbird and the Bluebird, all these species are members of the Finch and Sparrow family, subsisting mainly on seeds in winter.

Spring. Although considerable migratory movement among wintering Robins, Rusty Blackbirds, and others begins in February and early March, we consider the spring migration "officially" opened by the arrival of the early summer Warblers and Vireos during the last two weeks in March. The spring is the richest season in bird life because of the spectacular nature of the spring migration, bringing as it does within a few weeks an onrush of full-plumaged, singing birds, some of which settle down here and start nesting and others which pass on to the north. The last two weeks in March and the first three in April at Chapel Hill find most of the summer residents arriving, every day, almost, bringing a new one. The first individuals to arrive are, as a general rule, the birds which nest here, and not those which nest further north, which pass through later. Also several transient species put in their appearance during these weeks. However, the last two weeks in April and the first half of May is the real transient period when anything, however unexpected, may turn up. During the whole spring the winter resident species are continually leaving for northern nesting grounds, but since they do not announce their departure with such certainty as the summer birds announce their arrival, it is often hard to chart accurately their departure. For complete migration data, however, it is necessary to keep records of this class as much as possible.

The height of the transient period, the last week in April and the first week in May, is the climax to the whole spring migration at Chapel Hill. At this time the largest single day lists of the year are obtainable, because transients, summer residents, winter residents, and permanent residents are present, bringing together a greater variety of species than is possible at any other time of the year. Our largest single day list stands at 101 species recorded on May 5, 1934.

After this climax the spring migration quickly tapers off and "officially" closes with the departure of the last Black-poll Warbler between May 26 and June 1.

Nesting season. At this latitude the breeding season is relatively long, including not only the summer months but the spring as well. Many species regularly raise two broods a season, and some three; others, particularly those that start late, raise only one. We have actual breeding records for 73 species at Chapel Hill so far. These are starred in the list. At least 15 additional species undoubtedly breed, with a likelihood of others. Several species are present during the breeding season which probably do not breed here.

The English Sparrow is one of the earliest birds to begin nesting, often

commencing during February or March. We have a record of a Starling nest containing young on Feb. 27, 1932. The Great Horned Owl is said to lay in February, although we have no nesting records here. The latter part of March finds a number of birds beginning nesting operations provided the season is not too late. Carolina Wren, Tufted Titmouse, Carolina Chickadee, Cardinal, Bluebird, and Robin are among those that lay in March or early April. By May the nesting season is in full swing, with almost every species engaged in some phase. June finds the early nesters beginning a second brood, later nesters just getting started with the first. In July the season diminishes, and by the middle of August most species have given up family cares and are undergoing the fall molt. The Goldfinch is an exception: it does not begin to nest until July, and we have a record of an occupied nest on September 4. In the case of summer resident species the breeding individuals and particularly the young of the year frequently leave for the south before the species as a whole departs, individuals from further north taking their places, as has been shown through bird banding.

Songs, so characteristic of our small birds and forming one of their strongest esthetic attractions, should be mentioned in connection with the nesting season. In the South where warm weather and food are more abundant and the breeding season longer many species may be heard for a longer portion of the year than in the north. The song is at its best during the breeding season; some species sing only at this time, but others have a much longer song period. We have not made a special study of song periods, but we can safely say that the Carolina Wren is the only bird which sings the year round here. Its loud cheery song may be heard on any day, regardless of weather conditions. The Titmouse, Cardinal, and the Pine Warbler approach the Wren in length of song period. The Vireos, all of them, are persistent singers through the summer months; the Blue-headed Vireo, which comes nearest to being a resident species, is likely to be heard at any time. Luckily, two of the village's best songsters, the Mockingbird and the Wood Thrush, have long song periods, the latter extending to late summer and the former nearly all the year round. The Brown Thrasher, which ranks with the best, on the other hand rarely sings before the middle of March or after May.

Many winter resident species, although not nesting here, give us some samples of their songs, especially on the approach of spring. The White-throated Sparrow may be heard any warm day during its long stay here (October to May).

Fall. The fall migration offers a direct contrast to the spring migration in almost every respect. The spring migration is rapid and overwhelming. It comes quickly to a climax and rapidly to an end. The birds are in full plumage and full song; they are in a hurry to get north and start nesting. The fall migration, on the other hand, is long-drawn-out; there is no climax to speak of. The birds are in their dullest plumages and rarely sing; they are in no hurry to get south, at least during the greater part of the migration period. The southward movement at Chapel Hill begins as early as the middle of July with the return of the first Sandpipers, and continues right up until the cold weather of November.

By reason of its contrasting nature, however, the fall migration is of great significance to one who is becoming acquainted with local birds, a fact which is quite often overlooked by amateur students. Many transients are rare in the spring simply because they pass through a given locality within the space of a few days, while in the fall they tarry longer and are consequently commoner. The reverse is also true, but to a less general extent. Then, also, some few species seem to take different routes for their northward and southward journeys. Therefore, a study of both migrations is necessary in determining the status of a migratory species. The Blackburnian Warbler, for instance, is a rare bird in the spring and would be pronounced a rare species if only the spring migration were taken into consideration; in the fall, however, it is not uncommon for six weeks.

Of course the dull plumages, particularly among warblers and water birds, make identification of many species more difficult in the fall, but with the excellent books now available picturing both spring and fall, adult and immature plumages, the distinguishing characters of fall plumages, with some few exceptions, can be mastered without great difficulty.

Flocking, as in winter, is very characteristic of the fall. Not only birds of the same species but birds of different species, often of widely different habits, gather together in loose companies. The woods about Chapel Hill seem very quiet and absolutely devoid of bird life in September and October. But if one wanders about for a while, he is likely to run into a lot of birds at one time, a fall troop, as we call them; the woods for a short space are alive with birds. Not only migrant species are present, but also permanent resident species, especially Titmice and Chickadees, which seem to have caught some of the migratory spirit, so to speak. It should be pointed out that the birds are not actually

migrating at such a time, because almost all birds migrate at night in extended flights (their calls can often be heard in the darkness as they pass overhead); they are merely feeding and move slowly through the woods, so that one may easily follow a troop indefinitely. Sometimes the troop travels in circles or a series of circles, sometimes just aimlessly.

Flocking is also evident in the fields and on large bodies of water in fall.

The list. The following list of the birds of Chapel Hill is constructed along the lines of the usual briefly annotated local list. The nomenclature and sequence is that of the 4th (1931) edition of the American Ornithologists' Union *Check-list.* The common or book names are placed first because they are in more general use among ornithologists and in reality are more stable than the scientific names. In a few instances "local" names, which are in general use in this section of the country, are also included (For example "rain crow" or "red-bird"). Family names are included because the families form convenient groups. Other taxonomic data are unnecessary.

Where a species is divided into two or more recognized sub-species we have listed the appropriate form as given by the *Check-list.* In case two sub-species are listed as occurring through this region (for example, Northern and Southern Flicker), both forms are named but in the absence of specimens are treated as one, since sub-species cannot be distinguished in the field. Unless stated, the naming of sub-species is not based on specimens.

Following the name of the bird comes a brief statement of its status and relative abundance, and if it is a migratory species, our extreme (earliest and latest) dates of its occurrence. If our data do not supplant that of earlier lists or if the status of a species seems to have changed radically, separate mention is made of earlier observations.

Our nesting data are meager, since the study of such, except in a few special cases, has been incidental. Wherever we have them, however, nesting dates are included just to give a rough idea of when the species may be expected to nest.

In addition to the above, we have frequently included single words, phrases, or short sentences on the local habitat, the type of country where one could best look for the particular species.

Terms used. In describing the status of a bird the usual terms are used as follows: Permanent resident or resident—found the year around; summer resident (visitor)—here for breeding season but wintering farther south; winter resident (visitor)—wintering here but nesting

farther north; transient—passing through in spring or fall or both; casual visitant—of very irregular or accidental occurrence. Because a species is a "permanent resident" does not necessarily mean that it is not migratory. There may be a considerable shifting of individuals north and south, often involving a change in sub-species, although the species as a whole is always present.

In attempting to give some idea of relative abundance, we have adopted the following terms: Common, fairly common, uncommon, scarce, and rare. These terms should not be taken too literally; birds are such motile creatures, varying in abundance from time to time, so that one may gain different impressions at different times. "Common" and "scarce," particularly, cover a lot of ground. Also, it should be borne in mind that the terms are relative. "Irregular" and "local" are convenient terms which are also applied. In the case of water birds, for reasons already mentioned, we have refrained from attempting to indicate relative abundance, and have recorded only facts of observation.

Acknowledgments. We wish to express our special appreciation to Dr. J. M. Valentine, curator of the recently established University Museum of Natural History, for his encouragement and assistance in our bird work, to Mr. C. S. Brimley of Raleigh who has always had an active interest in our work and has made known to us several old Chapel Hill records which might have otherwise been overlooked, and to Warden John Sykes of University Lake who has taken a real interest in the birds and has helped us keep track of the water birds at the lake.—Eugene P. Odum.

The following list contains 195 named species. The symbol * indicates breeding record.

Family GAVIIDAE. Loons

COMMON LOON. *Gavia immer immer.* Transient visitor. Two specimens recorded by Pearson in 1898 remain the only postive records, but Warden Sykes at University Lake has on several occasions described large birds fitting the description of Loons which he saw in late fall, 1933 and 1934; chiefly coastwise.

Family COLYMBIDAE. Grebes

HOLBOELL'S GREBE. *Colymbus grisegena holboelli.* Like the Loon this species is chiefly a coastwise bird in winter, but it appears to occur inland more rarely. The only record here is a specimen taken by Prof. Atkinson in 1887.

HORNED GREBE. *Colymbus auritus.* Status much as with the preceding two species, but seems to be of more regular occurrence. We have records for November 12, 1931; October 23, 1932; March 26, 1933; and December 23, 1933.

PIED-BILLED GREBE. *Podilymbus podiceps podiceps.* Common transient and winter resident; it is almost a permanent resident, being recorded in every month but May and June (i.e., July 21–April 18), but there are no indications that this species breeds here, chiefly because there are no suitable places at present, though it is possible that it does breed somewhere not far from this locality.

Family PHALACROCORACIDAE. Cormorants

DOUBLE-CRESTED CORMORANT. *Phalacrocorax auritus auritus.* Rare transient. Single individuals were seen on May 21 and November 5, 1933, at University Lake (Odum).

Family ARDEIDAE. Herons and Bitterns

GREAT BLUE HERON. *Ardea herodias herodias.* Occurs sparingly throughout the year; commonest in late March and April; rare in winter. Not known to breed.

AMERICAN EGRET. *Casmerodius albus egretta.* Post-breeding-season visitor (i.e., after the nesting season is over on the coast, the birds wander inland and northward until driven south again at the approach of fall), July 2–September 25. During Pearson's time this bird was very rare, on the verge of extinction by plume hunters, but now with protection the bird has recovered some of its former numbers. Since the construction of University Lake it has been more or less frequent at Chapel Hill.

SNOWY EGRET. *Egretta thula thula.* Post-breeding-season visitor. Like the preceding, this species was once near extermination; today it is still much less common than the American Egret. Single birds were observed off and on by all of us between July 15 and September 12, 1933. This species is sometimes confused with the white immature birds of the next species.

LITTLE BLUE HERON. *Florida caerulea caerulea.* Common post-breeding-season visitor, June 18–September 30. Most of the individuals which visit us at this season are immature birds in white plumage commonly known as "little white cranes." They form a conspicuous feature of the lake in summer. The species has also been recorded twice in the spring, April 29, 1933, and May 5, 1934.

*EASTERN GREEN HERON. *Butorides virescens virescens.* Summer resident, April 2–October 4. Eggs June 7.

BLACK-CROWNED NIGHT HERON. *Nycticorax nycticorax hoactli.* Scarce spring transient, March 29–May 5. Also an immature bird either of this species or of a Yellow-crowned Night Heron was seen by Taylor July 6 and 7, 1933.

AMERICAN BITTERN. *Botaurus lentiginosus.* Has been observed throughout the year in every month except June and February, but is mostly a transient. Commonest in spring from March to May, less common in fall, rare in summer (July and August) and winter (December and January). No breeding records.

EASTERN LEAST BITTERN. *Ixobrychus exilis exilis.* Only one record, a bird seen by Odum May 24, 1931.

Family CICONIIDAE. Storks and Wood Ibises

WOOD IBIS. *Mycteria americana.* Immature male killed by G. S. MacNider, June 12, 1901, six miles south of town.

Family ANATIDAE. Swans, Geese, Ducks, and Allies

CANADA GOOSE. *Branta canadensis canadensis.* Transient. Warden Sykes reported geese from University Lake, fall of 1933. MacNider in his notes records wild geese flying over November 11, 1900. Old residents say they were not infrequent years ago. No recent bird student has seen any here.

COMMON MALLARD. *Anas platyrhynchos platyrhynchos.* Winter resident, November 5–May 7.

COMMON BLACK DUCK. *Anas rubripes tristis.* Winter resident. Usually outnumbers the preceding on the lake in winter.

AMERICAN PINTAIL. *Dafila acuta tzitzihoa.* Transient and less common winter resident, November 13–April 2.

BLUE-WINGED TEAL. *Querquedula discors.* Transient. Recorded September 17, 1932, April 17, September 12, 1933, September 19, 1934.

*WOOD DUCK. *Aix sponsa.* "Summer Duck." Resident in small numbers in suitable places. Breeds; adults with young only a little while out of the nest seen April 16, 1932, and May 7, 1933. In late summer small flocks often frequent the wooded portions of University Lake, but at other seasons they are not usually found on large bodies of open water.

REDHEAD. *Nyroca americana.* One record, March 12, 1933, a single bird observed by Jim Stephens.

RING-NECKED DUCK. *Nyroca collaris.* Winter resident. Closely resembles the Scaup, but with good binoculars at fair range one can easily make out the field marks (Male: white crescentic side mark in front of wing, white ring on bill, and dark back without any white. Female: ring bill and white eye ring).

CANVAS-BACK. *Nyroca valisineria.* Winter resident. In the winter of 1932–33 a small flock was observed continually, but it was rare in 1933–34.

LESSER SCAUP DUCK. *Nyroca affinis.* Winter resident, November 6–April 22. Also a single bird seen June 28, 1932, probably a non-breeding bird. This species seems to be more abundant in migration than the Ring-neck, but the majority of wintering birds seems to be individuals of the latter. The Greater Scaup (*Nyroca marila*), a more coastwise bird, may also occur in the Scaup flocks, but except under unusual conditions the two are not readily distinguishable in the field. Two specimens of scaup taken by Taylor proved to be Lesser Scaup.

AMERICAN GOLDEN-EYE. *Glaucionetta clangula americana.* Transient and winter visitor, March 26, April 2, November 17, and January 6.

BUFFLE-HEAD. *Charitonetta albeola.* One record, a male and two females seen November 17, 1933 (Odum).

RUDDY DUCK. *Erismatura jamaicensis rubida.* Winter resident. Regularly observed 1932–33, rare 1933–34.

HOODED MERGANSER. *Lophodytes cucullatus.* Winter resident, November 5–March 12.

RED-BREASTED MERGANSER. *Mergus serrator.* Winter, December 23, 1933; December 23, 1934; January 2, 1935.

Family CATHARTIDAE. American Vultures

*TURKEY VULTURE. *Cathartes aura septentrionalis.* "Turkey Buzzard." Common permanent resident. Breeds; nest with young in May, 1931.

*BLACK VULTURE. *Coragyps atratus atratus.* "Carrion Crow." Resident, occurs less regularly than the preceding and usually in small flocks. One breeding record, May 5, 1933 (young in nest).

Family ACCIPITRIIDAE. Kites, Hawks, and Allies

SHARP-SHINNED HAWK. *Accipiter velox velox.* Winter resident, September 5–May 15. Uncommon. Perhaps also a rare summer resident and breeder as the May 15 record (specimen taken) and summer records from nearby localities would indicate.

*COOPER'S HAWK. *Accipiter cooperii.* Resident. Commonest in winter and during the migrations. This and the preceding species, sometimes known as "blue darters," are slim, long-tailed, short-winged, slate-colored, bird-eating hawks, generally our only harmful Hawks. They stand in direct contrast with the three following species of genus Buteo which are heavy, long-winged, soaring, rodent-eating, conspicuous Hawks, generally beneficial. Eggs April 29, 1898 (Pearson).

EASTERN RED-TAILED HAWK. *Buteo borealis borealis.* Resident. Most conspicuous in winter. Lowgrounds.

*NORTHERN RED-SHOULDERED HAWK. *Buteo lineatus lineatus.* Resident. More widely distributed than the Red-tail. Especially noisy in early spring. Young birds in nest April 28.

*BROAD-WINGED HAWK. *Buteo platypterus platypterus.* Fairly common summer resident, April 7–September 6. Two nesting records: two eggs May 2, 1932; young half grown June 13, 1933. Wooded hillsides alternating with small meadows or fields.

SOUTHERN BALD EAGLE. *Haliaeetus leucocephalus leucocephalus.* Rare visitant during migrations. Single birds observed by Pearson, March 27, 1898; Valentine, October 15 (about), 1934; and Breckenridge, November 24, 1934.

MARSH HAWK. *Circus hudsonius.* Irregular winter resident, August 19–March 26. The grassy flats and treeless marshes which the Marsh Hawk likes are generally lacking here.

OSPREY. *Pandion haliaetus carolinensis.* "Fish Hawk." Mostly transient. Common from the middle of March to May and from late August to October, but it has been observed at other times of the year: July 7, July 22, and December 23, December 24. Not known to breed.

Family FALCONIDAE. Caracaras and Falcons

EASTERN PIGEON HAWK. *Falco columbarius columbarius.* Rare transient. One observed at rest and in flight by Jim Stephens, May 3, 1934.

*EASTERN SPARROW HAWK. *Falco sparverius sparverius.* Resident. Not common. Pearson recorded it as "moderately common" in 1899 and mentioned that a pair roosted under the eaves of New East building on the campus. Eggs May 1899 (Pearson).

Family PERDICIDAE. Partridges and Quails

*EASTERN BOB-WHITE. *Colinus virginianus virginianus.* Common resident, but fluctuating in numbers from year to year.

Family PHASIANIDAE. Pheasants

RING-NECKED PHEASANT. *Phasianus colchicus torquatus.* Although not a native species, it is being introduced, but as yet with little success in this region. Dr. R. B. Lloyd, of Carrboro, has released several hundred. We have seen a few in the wild state.

Family MELEAGRIDIDAE. Turkeys

*EASTERN TURKEY. *Meleagris gallopavo silvestris.* Resident. Still fairly common.

Family RALLIDAE. Rails, Gallinules, and Coots

KING RAIL. *Rallus elegans elegans.* Winter resident. Very secretive, but often noisy. Marshy, reedy places.

VIRGINIA RAIL. *Rallus limicola limicola.* Winter resident. Similar to the King Rail in habits. Taken February 28 (Taylor).

SORA. *Porzana carolina.* Transient, September 8–December 23; no positive spring records.

FLORIDA GALLINULE. *Gallinula chloropus cachinnans.* One record, a specimen picked up alive on a road by Bill Hogan and procured by Odum October 16, 1934.

AMERICAN COOT. *Fulica americana americana.* Mostly fall transient, occasional in winter and spring, October 23–April 8. May 2, 1901 (G. S. MacNider).

Family CHARADRIIDAE. Plovers, Turnstones, and Surf-birds

*KILLDEER. *Oxyechus vociferus vociferus.* Resident. Commonest in winter.

Family SCOLOPACIDAE. Woodcock, Snipe, and Sandpipers

AMERICAN WOODCOCK. *Philohela minor.* Resident. Commonest in fall migration, late November and early December. Wet thickets.

WILSON'S SNIPE. *Capella delicata.* Winter resident, September 9–May 12. Occurs in large flocks in spring. Also, one seen June 18, 1934 (Breckenridge). Wet or marshy meadows.

SPOTTED SANDPIPER. *Actitis macularia.* Common transient, April 12–May 21 and July 15–September 21. Mud flats, exposed creek banks and lake shores.

EASTERN SOLITARY SANDPIPER. *Tringa solitaria solitaria.* Common transient, April 18–May 20 and July 16–October 15. Often associated with the preceding.

GREATER YELLOW-LEGS. *Totanus melanoleucus.* Scarce transient, May 3; October 15–November 18.

LESSER YELLOW-LEGS. *Totanus flavipes.* Scarce transient. So far recorded only in spring, April 27–May 3.

PECTORAL SANDPIPER. *Pisobia melanotos.* Scarce transient. Specimens taken March 29, 1931; November 18, 1933; and September 19, 1934.

LEAST SANDPIPER. *Pisobia minutilla.* Scarce transient. So far recorded only in spring, May 5–May 21.

Family LARIDAE. Gulls and Terns

HERRING GULL. *Larus argentatus smithsonianus.* Casual visitant, spring and fall. Normally residing on the coast, this "sea gull" sometimes wanders or is driven far inland. A large flock appeared on the lake April 16, 1933, and some remained until April 22. In the fall of 1934 they again appeared, and exhausted birds were secured December 1 and December 4. In both cases their appearance followed widespread heavy rains.

BONAPARTE'S GULL. *Larus philadelphia.* Rare visitant; one record, an individual in winter plumage observed carefully by Odum November 13, 1932, at the lake.

COMMON TERN. *Sterna hirundo hirundo.* Rare visitant; one bird observed October 15, 1933, at the lake (Taylor, Breckenridge, and Odum).

BLACK TERN. *Chlidonias nigra surinamensis.* Scarce fall transient, August 24–September 17. Also two immature birds June 28, 1932. Unlike most Gulls and Terns of the Atlantic coast the Black Tern occurs regularly inland. During migration subsists mainly on insects taken on the wing.

Family COLUMBIDAE. Pigeons and Doves

*EASTERN MOURNING DOVE. *Zenaidura macroura carolinensis.* Permanent resident. Long breeding season.

PASSENGER PIGEON. *Ectopistes migratorius.* This once abundant now extinct species obtains a place on the list by virtue of one taken by K. P. Battle, Jr., 1887.

Family CUCULIDAE. Cuckoos, Roadrunners, and Anis

*YELLOW-BILLED CUCKOO. *Coccyzus americanus americanus.* "Rain crow." Fairly common summer resident. April 25–October 17.

BLACK-BILLED CUCKOO. *Coccyzus erythropthalmus.* Apparently occurring only as a rare transient; October 3, 1932, and September 10, 1934.

Family TYTONIDAE. Barn Owls

BARN OWL. *Tyto alba pratincola.* Few records. Specimen taken January 26, 1909, by T. E. Hester. Two have been brought to the Zoology Department, one of them to Dr. H. V. Wilson eighteen years ago, the other killed by C. L. Rich near Mt. Carmel (2 miles south of town) on May 15, 1931. Mr. Roy Brown tells us that an owl which he is positive was a Barn Owl spent the winter of 1930–31 in his barn. Nocturnal and very secretive, the presence of this owl is often not suspected.

Family STRIGIDAE. Typical Owls

*EASTERN SCREECH OWL. *Otus asio naevius.* Resident, fairly common; locally present in town.

GREAT HORNED OWL. *Bubo virginianus virginianus.* Resident, scarce. Occasionally specimens dead or alive have been brought in from the surrounding countryside, but in the immediate vicinity of town, at least, it seems to be very rare. Several times we have thought that we heard it at a distance, but could not be positive; we have never seen one in the wild here. Pearson in 1898 gives it status then as follows: "For a large bird the horned owl is a fairly common resident in this region."

NORTHERN BARRED OWL. *Strix varia varia.* "Hoot owl." Common resident; in timber tracts and lowgrounds. Very noisy at times and frequently attracts the attention of residents in the wooded outskirts of town.

Family CAPRIMULGIDAE. Goatsuckers

CHUCK-WILL'S-WIDOW. *Antrostomus carolinensis.* Scarce spring transient and perhaps rare summer resident, April 16, 1930; April 23, 1931; April 24, 1934. Pearson heard one May 20, 1899. "During the summers of 1902 and 1903 I quite frequently heard the chuck-will's-widow calling in the woods bordering the campus" (G. S. MacNider).

EASTERN WHIP-POOR-WILL. *Antrostomus vociferus vociferus.* Common summer resident. Earliest arrival, March 31.

EASTERN NIGHTHAWK. *Chordeiles minor minor.* Summer resident, April 25–September 20. Commonest during migrations, especially in fall from the middle of August to the middle of September. April 11–October 7 (Feild).

Family MICROPODIDAE. Swifts

*CHIMNEY SWIFT. *Chaetura pelagica.* Common summer resident, April 4–October 10. March 31 (Feild).

Family TROCHILIDAE. Hummingbird

*RUBY-THROATED HUMMINGBIRD. *Archilochus colubris.* Common summer resident, April 4–October 10.

Family ALCEDINIDAE. Kingfishers

*EASTERN BELTED KINGFISHER. *Megaceryle alcyon alcyon.* Resident. Uncommon in winter, common in summer. Occupied nests, April 12 and May 1. Creeks, University Lake, and ponds.

Family PICIDAE. Woodpeckers

NORTHERN FLICKER. *Colaptes auratus luteus.*

*SOUTHERN FLICKER. *Colaptes auratus auratus.* Common resident. Eggs May 20. Frequents woods and more open country alike.

*SOUTHERN PILEATED WOODPECKER. *Ceophloeus pileatus pileatus.* Resident. A few can always be found. A pair nested almost within the town limits in 1931, and again in 1934 in another unexpected location.

*RED-BELLIED WOODPECKER. *Centurus carolinus.* Common resident, especially along water courses.

*RED-HEADED WOODPECKER. *Melanerpes erythrocephalus.* Common resident, but local in distribution. Less common in winter. Often conspicuous on the University campus. Eggs May 7.

YELLOW-BELLIED SAPSUCKER. *Sphyrapicus varius varius.* Common winter resident, October 3–April 17. The only injurious woodpecker. April 26 (Feild).

*SOUTHERN HAIRY WOODPECKER. *Dryobates villosus audubonii.* Common resident. A bit more shy than the downy.

*SOUTHERN DOWNY WOODPECKER. *Dryobates pubescens pubescens.* Common resident. Everywhere.

RED-COCKADED WOODPECKER. *Dryobates borealis.* Recorded only by Alexander Feild: "I found it a not uncommon bird in Battle's Park and other neighboring woods—seen by me five times in the months of March and April, 1909, the latest being on April 17."

Family TYRANNIDAE. Flycatchers

EASTERN KINGBIRD. *Tyrannus tyrannus.* Common summer resident. Earliest date April 17. Open country. September 3 (Feild).

*NORTHERN CRESTED FLYCATCHER. *Myiarchus crinitus boreus.* Common summer resident, April 16–September 25. Woods.

*EASTERN PHOEBE. *Sayornis phoebe.* Common resident. More common in winter. Under bridges and porch roofs are its favorite nesting places.

*ACADIAN FLYCATCHER. *Empidonax virescens.* Common summer resident, April 25–September 23. Eggs June 1. Characteristic of the many heavily-wooded streams around Chapel Hill.

*EASTERN WOOD PEWEE. *Myiochanes virens.* Common summer resident, April 24–October 14. Eggs May 10. Everywhere in woods.

Family ALAUDIDAE. Larks

NORTHERN HORNED LARK. *Otocoris alpestris alpestris.*

PRAIRIE HORNED LARK. *Otocoris alpestris praticola.* Irregular in winter. Observed in only two winters out of six: 1932–33 and 1933–34 at irregular dates from November 10 to January 6. November 23, 1898 (Pearson).

Family HIRUNDINIDAE. Swallows

TREE SWALLOW. *Iridoprocne bicolor.* Common transient, April 8–April 28 and September 10–September 19.

BANK SWALLOW. *Riparia riparia riparia.* Scarce transient, April 16–Mary 12. No fall records.

*ROUGH-WINGED SWALLOW. *Stelgidopteryx ruficollis serripennis.* "Bank Swallow." Common summer resident. Earliest date March 28. Eggs May 21; young in nest June 25. Water.

BARN SWALLOW. *Hirundo erythrogaster.* Common transient, April 8–May 21 and August 10–September 19.

NORTHERN CLIFF SWALLOW. *Petrochelidon albifrons albifrons.* Scarce transient, May 3, September 10, and September 12.

*PURPLE MARTIN. *Progne subis subis.* Common transient, particularly in late summer, but only, at present, a rare summer resident. March 22–September 10. We know of no stable colony in our vicinity at the present time, but there have been nesting birds in the town in the past few years, and birds are now occasionally seen during the breeding season.

Family CORVIDAE. Jays and Crows

*NORTHERN BLUE JAY. *Cyanocitta cristata cristata.* Common resident. Eggs May 7.

EASTERN CROW. *Corvus brachyrhynchos brachyrhynchos.*

*SOUTHERN CROW. *Corvus brachyrhynchos paulus.* Common resident.

Family PARIDAE. Titmice

*CAROLINA CHICKADEE. *Penthestes carolinensis carolinensis.* Common resident. Eggs March 30. Woods and wooded places.

*TUFTED TITMOUSE. *Bacolophus bicolor.* Common resident. Eggs March 29. Woods.

Family SITTIDAE. Nuthatches

*WHITE-BREASTED NUTHATCH. *Sitta carolinensis carolinensis.* Common resident. Large oaks.

RED-BREASTED NUTHATCH. *Sitta canadensis.* Irregular winter visitor, October 10–May 21. Observed in winters 1929–30, 1931–32, 1933–34. Entirely absent in other winters. Pines, usually high up among small limbs.

*BROWN-HEADED NUTHATCH. *Sitta pusilla pusilla.* Local resident. Bird digging cavity March 18; eggs March 29. Open pine woods. Except at breeding season almost always observed in companies, probably family groups.

Family CERTHIDAE. Creepers

BROWN CREEPER. *Certhia familiaris americana.* Fairly common winter resident, October 10–April 20.

Family TROGLODYTIDAE. Wrens

*EASTERN HOUSE WREN. *Troglodytes aedon aedon.* Summer resident. Several years ago we considered it scarce and as occurring only as a transient, but in the past two or three years it has become a fairly common, though local, breeder.

EASTERN WINTER WREN. *Nannus hiemalis hiemalis.* Common winter resident, September 23–April 28. Tangles near water.

*CAROLINA WREN. *Thryothorus ludovicianus ludovicianus.* Common resident. Often nests in unexpected places about dwellings. Eggs March 26.

BEWICK'S WREN. *Thryomanes bewicki bewicki.* Winter visitor. Our only record is a bird which Dr. Valentine observed off and on at his home February and March 1935. Sang frequently.

LONG-BILLED MARSH WREN. *Telmatodytes palustris palustris.* Scarce transient, April 28–May 9 and September 20–October 7.

SHORT-BILLED MARSH WREN. *Cistothorus stellaris.* Scarce transient, April 28–May 12 and August 19–October 7.

Family MIMIDAE. Mockingbirds and Thrashers

*EASTERN MOCKINGBIRD. *Mimus polyglottos polyglottos.* Common resident. Open locations, especially near habitations.

*CATBIRD. *Dumetella carolinensis.* Common summer resident, April 18–October. Also recorded in early winter: November 24, 1934; December 23, 1931, 1933, and 1934. And March 21, 1935. Shrubbery and thickets.

*BROWN THRASHER. *Toxostoma rufum.* Common resident, less common in winter. Eggs April 30. Shrubbery and thickets.

Family TURDIDAE. Thrushes, Bluebirds, Stonechants, Solitaires

EASTERN ROBIN. *Turdus migratorius migratorius.*

*SOUTHERN ROBIN. *Turdus migratorius achrusterus.* Common resident. Abundant during migrations. In winter, flocks in woods and creek bottoms.

*WOOD THRUSH. *Hylocichla mustelina.* Common summer resident, April 7–October 13. Eggs May 10. Very characteristic of all woodlands.

EASTERN HERMIT THRUSH. *Hylocichla guttata faxoni.* Common winter resident, October 21–April 23. We have heard this famed songster sing not infrequently while with us, but although it sometimes reaches the volume, it never approaches the quality of tone which it achieves in its northern nesting grounds.

OLIVE-BACKED THRUSH. *Hylocichla ustulata swainsoni.* Common transient, April 22–May 18 and September 18–October 15. Several specimens have been taken.

VEERY. *Hylocichla fuscescens fuscescens.* Uncommon transient, May 8–May 23; no fall records.

*EASTERN BLUEBIRD. *Sialia sialis sialis.* Common resident. Eggs April 5. Gathers in small flocks in winter.

Family SYLVIIDAE. Gnatcatchers and Kinglets

*BLUE-GRAY GNATCATCHER. *Polioptila caerulea caerulea.* Common summer resident, March 24–October 4. Begins nesting almost immediately on its arrival in spring. Along water courses.

EASTERN GOLDEN-CROWNED KINGLET. *Regulus satrapa satrapa.* Common winter resident, October 10–April 17. Pine woods.

EASTERN RUBY-CROWNED KINGLET. *Corthylio calendula calendula.* Common winter resident, September 29–May 6. Less common than the preceding in winter, but becomes abundant in spring migration.

Family MOTACILLIDAE. Wagtails and Pipits

AMERICAN PIPIT. *Anthus spinoletta rubescens.* Winter resident, November 7–April 4. Seems to be commonest in early winter. Flocks in open fields. October 17 (Feild).

Family BOMBYCILLIDAE. Waxwings

CEDAR WAXWING. *Bombycilla cedrorum.* Resident. Irregular in occurrence at all times and scarce in summer; only a few scattered records between May and October. No breeding records.

Family LANIIDAE. Shrikes

LOGGERHEAD SHRIKE. *Lanius ludovicianus ludovicianus.*

MIGRANT SHRIKE. *Lanius ludovicianus migrans.* Scarce; irregular, scattered dates, mostly in winter, as follows: December 10, 1930; November 15, 1931; January 4, September 9, 1932; January 1 and 3, July 10, 1933; February 24, April 29, September 10 and 15, 1934.

Family STURNIDAE. Starlings

*STARLING. *Sturnus vulgaris vulgaris.* Common resident. Introduced into this country in 1891. As nearly as we can tell was first observed in Chapel Hill in the winter of 1925. Now breeds commonly. Nest containing young birds noted February 27 (Breckenridge).

Family VIREONIDAE. Vireos

*WHITE-EYED VIREO. *Vireo griseus griseus.* Common summer resident, earliest arrival March 25. Thickets and tangles, especially along water.

*YELLOW-THROATED VIREO. *Vireo flavifrons.* Common summer resident, April 3–October 7. Inhabits woods and shade trees as the Red-eye, but not so numerous.

BLUE-HEADED VIREO. *Vireo solitarius solitarius.*

*MOUNTAIN SOLITARY VIREO. *Vireo solitarius alticola.* The Solitary Vireo is most common as a transient from about March 16 to May and from the middle of September to November, but is also a local summer resident in certain pine woods and occurs sparingly in winter (January 2 and 3, 1934). *Alticola* is the breeding form and *solitarius* the transient form as given by the *A. O. U. Check-List.*

*RED-EYED VIREO. *Vireo olivaceus.* Common summer resident, April 16–October 11. Everywhere in woods.

Family COMPSOTHLYPIDAE. Wood Warblers

*BLACK AND WHITE WARBLER. *Mniotilta varia.* Summer resident, commonest during the migrations, March 18–October 12. Eggs May 10

PROTHONOTARY WARBLER. *Protonotaria citrea.* One record so far, May 5, 1934 (Taylor, Breckenridge; New Hope swamp). A swamp-loving lower austral species; reported as regular summer resident at Raleigh.

WORM-EATING WARBLER. *Helmitheros vermivorus.* Scarce transient, April 27–May 5 and August 31–September 5; one summer record, June 27, 1931. A low-ranging bird frequenting thickets.

GOLDEN-WINGED WARBLER. *Vermivora chrysoptera.* Scarce but regular transient, more frequent in fall; April 28–May 4 and August 30–September 12.

BLUE-WINGED WARBLER. *Vermivora pinus.* Scarce transient: May 2, 3, and September 3, 7, 20.

BREWSTER'S WARBLER. *Vermivora leucobronchialis.* This hybrid between the two preceding species was observed under excellent conditions August 25, 1932 (Odum).[1] A specimen taken at Raleigh September 6, 1888, is the only other record for the state.

TENNESSEE WARBLER. *Vermivora peregrina.* Scarce fall transient, September 12–October 14. Rare in spring, specimen taken by Taylor May 3, 1932, and another seen by Dr. Valentine May 2, 1932, are our only records which, however, are the first spring records for the state.[2] It has been previously thought that the Tennessee Warbler migrates north wholly by way of the Mississippi Valley, but regular spring records from Washington, D. C., as well as our records would indicate that this is not entirely true.

[1] See "The Auk," Jan., 1933 (Vol. L, No. 1).

[2] *Ibid.*

NORTHERN PARULA WARBLER. *Compsothlypis americana pusilla.*

SOUTHERN PARULA WARBLER. *Compsothlypis americana americana.* Summer resident, April 7 to October 11, but apparently does not breed in this vicinity. It is most common in late summer and fall and least common at breeding time (May, June); however, singing individuals have been observed throughout the latter period. The species has been reported breeding in many other parts of the state, especially in the eastern section where *Usnea* "moss" (lichen), in which it so often builds, is plentiful. A bird of the tree tops. April 3 (Feild).

*EASTERN YELLOW WARBLER. *Dendroica aestiva aestiva.* Summer resident, not common; earliest arrival April 7. Fledglings observed July 7. September 20 (Feild).

MAGNOLIA WARBLER. *Dendroica magnolia.* Transient, common in fall, less common in spring: May 11–May 17 and August 29–October 19.

CAPE MAY WARBLER. *Dendroica tigrina.* Transient, April 21–May 7 and October 2–October 29. Usually a rather rare bird but sometimes occurs in numbers as between October 15 and 25, 1933.

BLACK-THROATED BLUE WARBLER. *Dendroica caerulescens caerulescens.* Common transient, commonest in spring; April 17–May 20 and September 8–October 10.

MYRTLE WARBLER. *Dendroica coronata.* Common winter resident, October 10–May 16. In April and early May it becomes very abundant, the wintering numbers being increased many fold by migrating birds from further south.

BLACK-THROATED GREEN WARBLER. *Dendroica virens virens.* Transient, fairly common in fall, less common in spring; April 19–May 24 and September 15–October 10.

BLACKBURNIAN WARBLER. *Dendroica fusca.* Transient, rare in spring, common in fall; April 30–May 19 and August 31–October 11.

*YELLOW-THROATED WARBLER. *Dendroica dominica dominica.* Common summer resident, March 18–October 6. Commonest along the creeks but also nests in upland woods.

CHESTNUT-SIDED WARBLER. *Dendroica pennsylvanica.* Transient, commonest in fall; April 25–May 15 and August 25–September 29.

BAY-BREASTED WARBLER. *Dendroica castanea.* Transient, rare in spring, May 11 and 12, 1933, only records; apparently much more common in fall. Although the Bay-breast and the next species, the Blackpoll, are very different in the spring plumages they are so much alike in the fall that identification without specimens is hazardous; if there is a large distinct chestnut side patch the bird can be named a Bay-breast,

but if there is little or no chestnut, as in the majority of birds, positive identification of the living bird, we think, is impossible. Therefore, we will say that a specimen taken by Odum October 7, 1934 (and two taken by Pearson October 2 and 8, 1897) are the only positive fall records, but that we have enough fairly positive records (chestnut-sided individuals) to indicate that the species is not uncommon in the fall.

BLACK-POLL WARBLER. *Dendroica striata.* Transient, very common in spring, April 20–June 1, apparently much rarer in fall. We have a number of sight records but are inclined to think some of them at least should fall under the Bay-breast, therefore, all are discarded. The only positive fall records are: Single specimens taken by Breckenridge September 1933, Odum October 14, 1934, and Pearson October 9, 1897. More specimens will have to be taken to clarify the fall status of the Bay-breast and the Black-poll here.[3]

*NORTHERN PINE WARBLER. *Dendroica pinus pinus.* Common resident. Eggs April 15. Almost a part of the pines themselves.

*NORTHERN PRAIRIE WARBLER. *Dendroica discolor discolor.* Common, somewhat local summer resident; April 10–October 1. Bush covered fields.

PALM WARBLER. *Dendroica palmarum palmarum.*

YELLOW PALM WARBLER. *Dendroica palmarum hypochrysea.* Irregular transient, March 23–April 29 and September 11–October 25.

*OVENBIRD. *Sieurus aurocapillus.* Common summer resident, commonest during the migrations, April 5–October 8. Eggs May 12. Woods with not too much undergrowth.

NORTHERN WATER-THRUSH. *Seiurus noveboracensis noveboracensis,* Common transient, April 22–May 16 and August 28–October 3. Very similar to the next in plumage but notes quite different.

*LOUISIANA WATER THRUSH. *Seiurus motacilla.* Common summer resident. Earliest arrival, March 18. Streams.

*KENTUCKY WARBLER. *Oporornis formosus.* Common summer resident, earliest arrival, April 28. Damp ravines.

NORTHERN YELLOW-THROAT. *Geothlypis trichas brachidactyla.*

*MARYLAND YELLOW-THROAT. *Geothlypis trichas trichas.* Common

[3] In a recent article (Wilson Bulletin, Sept. 1934) on the distribution of these two warblers in the Southeast, Thomas Burleigh concluded after field work in western North Carolina, South Carolina, and Georgia that the Black-poll in fall, south of Washington, D. C., at least, migrates chiefly on the coast and is therefore rare in the interior at that season. This agrees with the facts set down above, except that the Black-poll does occur at Chapel Hill in fall; how common it is we can not say as yet.

summer resident, March 24–October 18. Also December 23, 1934. Everywhere in weeds, tangles, and thickets in open country.

*YELLOW-BREASTED CHAT. *Icteria virens virens.* Common summer resident, April 22–September 20. Thickets in open country.

*HOODED WARBLER. *Wilsonia citrina.* Common summer resident, April 9–September 28. Eggs May 11. Lush growth along woodland streams.

WILSON'S WARBLER. *Wilsonia pusilla pusilla.* Rare transient, September 23, 1933, only record (Odum, Breckenridge).

CANADA WARBLER. *Wilsonia canadensis.* Uncommon transient, May 5–May 17 and August 29–September 16.

*AMERICAN REDSTART. *Septophaga ruticilla.* Common summer resident, April 8–October 11. Eggs May 19. Abundant everywhere in woods during migrations, restricted to water courses during breeding season.

Family PLOCEIDAE. Weaver Finches

*ENGLISH SPARROW. *Passer domesticus domesticus.* Common resident; fortunately not over abundant at Chapel Hill.

Family ICTERIDAE. Meadowlarks, Blackbirds, Orioles

BOBOLINK. *Dolichohyx oryzivorus.* Irregular transient, April 13–May 5 and September 10–September 20. May 20 (Pearson), April 3, 1908 (Feild).

EASTERN MEADOWLARK. *Sturnella magna magna.*

*SOUTHERN MEADOWLARK. *Sturnella magna argutula.* "Field Lark." Common transient, fairly common winter resident, local summer resident. Eggs May 15. Grassy fields.

*EASTERN RED-WINGED BLACKBIRD. *Agelaius phoeniceus phoeniceus.* Common resident. Large flocks during migrations and in winter; breeds in colonies in suitable marshy places.

*ORCHARD ORIOLE. *Icterus spurius.* Fairly common summer resident, April 23–August 1. Groves in vicinity of open country.

BALTIMORE ORIOLE. *Icterus galbula.* Scare transient; May 4 (1930) and August 23–September 10.

RUSTY BLACKBIRD. *Euphagus carolinus.* Winter resident, commonest during the migrations, November 5–April 22. October 17, 1900 (G. S. MacNider).

PURPLE GRACKLE. *Quiscalus quiscula quiscula.*

BRONZED GRACKLE. *Quiscalus quiscula aeneus.* Transient and less

AGRICULTURE LIBRARY JAN 11 193

common winter resident, October 7–March 28. Of six specimens of grackle taken five have been Bronzed and one Purple.

COWBIRD. *Molothrus ater ater.* Apparently rare. Two records, December 18 and 23, 1934.

Family THRAUPIDAE. Tanagers

SCARLET TANAGER. *Piranga erythromelas.* Common transient, April 26–May 18 and September 16–October 15.

*SUMMER TANAGER. *Piranga rubra rubra.* "Summer redbird." Common summer resident, April 7–October 1. Woods.

Family FRINGILLIDAE. Grosbeaks, Finches, Buntings, Sparrows

*EASTERN CARDINAL. *Richmondena cardinalis cardinalis.* "Redbird." Common resident. Eggs April 5.

ROSE-BREASTED GROSBEAK. *Hedymeles ludovicianus.* Uncommon transient, April 24–May 9 and September 18–October 12.

*EASTERN BLUE GROSBEAK. *Guiraca caerulea caerulea.* Uncommon summer resident, April 28–September 12.

*INDIGO BUNTING. *Passerina cyanea.* Common summer resident, earliest arrival April 25. Open country.

EASTERN EVENING GROSBEAK. *Hesperiphona vespertina.* Two individuals taken by Dr. W. C. Coker March 8, 1922.

EASTERN PURPLE FINCH. *Carpodacus purpureus purpureus.* Common winter resident, September 12–April 24. Often very common in spring feeding on buds of elms and other trees.

NORTHERN PINE SISKIN. *Spinus pinus pinus.* Erratic winter visitor, December 12–January 10; observed winters of 1931–32 and 1933–34. April 23–May 6, 1911 (Feild).

*EASTERN GOLDFINCH. *Spinus tristis tristis.* Common resident. Young in nest September 4. Like the Purple Finch very conspicuous in budding trees in early spring. Flocks for a large part of the year.

RED-EYED TOWHEE. *Pipilo erythrophthalmus erythrophthalmus.* Common winter resident, October to May, rare summer resident. Pair observed continually summer of 1931 and at another place in 1932, but no nest found; immature bird with streaked breast July 21, 1930.

EASTERN SAVANNAH SPARROW. *Passerculus sandwichensis savanna.*, Common winter resident, September 9–May 12. One taken June 22 1933, (Taylor) was badly infected with parasitic worms. Grassy fields, damp or dry.

EASTERN GRASSHOPPER SPARROW. *Ammodramus savanarum aus-*

tralis. Uncommon summer resident, earliest arrival April 23. Pearson (1898) states "seen in winter and spring," but gives no specific dates.

EASTERN HENSLOW SPARROW. *Passerherbulus henslowi susurrans*. Not uncommon summer resident, April 28–October 7. As far as we are aware this species has not been reported summering south of northern Viriginia.[4] Female ready to lay taken (Taylor) and several pairs have show unmistakable evidences of breeding. Damp, lush meadows.

EASTERN VESPER SPARROW. *Pooecetes gramineus gramineus*. Irregular winter visitor, October 28–April 24.

*BACHMAN'S SPARROW. *Aimophila aestivalis bachmani*. Rare summer resident. Birds have been observed and heard at at least two separate localities (Odum). Nest recorded and nesting bird taken by Atkinson.

SLATE-COLORED JUNCO. *Junco hyemalis hyemalis*. "Snowbird." Common winter resident, October 22–May 4. Everywhere.

EASTERN TREE SPARROW. *Spizella arborea arborea*. One seen with White-throats January 4, 1935, by Dr. Valentine. Attempts to collect failed. "Listed by Prof. Atkinson probably as a winter occurrence" (Pearson); the latter statement alone in the absence of details or specimens would not be enough to keep the species on the list, in our opinion.

*EASTERN CHIPPING SPARROW. *Spizella passerina passerina*. Common summer resident, March to November, local and irregular winter resident; observed winters of 1931–32 and 1933–34. Lawns and gardens in summer.

*EASTERN FIELD SPARROW. *Spizella pusilla pusilla*. Common resident. Bush and brier covered fields.

WHITE-THROATED SPARROW. *Zonotrichia albicollis*. Common winter resident, September 29–May 17. Everywhere.

EASTERN FOX SPARROW. *Passerella iliaca iliaca*. Fairly common winter resident, November 5–April 7. Thickets.

SWAMP SPARROW. *Melospiza georgiana*. Common winter resident, October 6–May 21. Damp, boggy, marshy or swampy places.

EASTERN SONG SPARROW. *Melospiza melodia melodia*. Common winter resident, September 20–May 3. Thickets and hedgerows, especially along water.

THE HYPOTHETICAL LIST

(Records of the following species are not considered positive)

GREEN-WINGED TEAL. *Nettion carolinense*. March 5, 1934, not positive of identification (Breckenridge and Hairston). Should occur.

[4] See "The Auk," April 1933.

AMERICAN MERGANSER. *Mergus merganser americanus.* March 22, 1934, seven large mergansers, identification not positive. Should occur.

PHILADELPHIA VIREO. *Vireo philadelphicus.* May 2, one bird, not absolutely sure (Dr. Valentine). A rare transient species.

LINCOLN SPARROW. *Melospiza lincolni lincolni.* April 28, not positive (Dr. Valentine). A more western species; would be casual here in migrations.

APPENDIX

A LIST OF THE SPECIES FIRST RECORDED DURING OUR WORK, 1928–1935: 50 SPECIES

Horned Grebe
Double-crested Cormorant
Snowy Egret
Little-blue Heron
Black-crowned Night Heron
Least Bittern
Mallard
Black Duck
American Pintail
Blue-winged Teal
Redhead
Ring-neck Duck
Canvas-back
Lesser Scaup
American Golden-eye
Buffle-head
Ruddy Duck
Hooded Merganser
Red-breasted Merganser
Osprey
Pigeon Hawk
Ring-necked Pheasant (introduced)
King Rail
Virginia Rail
Florida Gallinule
Greater Yellowlegs
Lesser Yellowlegs
Pectoral Sandpiper
Least Sandpiper
Herring Gull
Bonaparte's Gull
Common Tern
Black Tern
Black-billed Cuckoo
Bank Swallow
Cliff Swallow
Red-breasted Nuthatch
Bewick's Wren
Long-billed Marsh Wren
Short-billed Marsh Wren
Starling (introduced)
Prothonotary Warbler
Golden-winged Warbler
Blue-winged Warbler
Brewster's Warbler (a hybrid)
Tennessee Warbler
Wilson's Warbler
Canada Warbler
Cowbird
Henslow Sparrow

UNIVERSITY OF NORTH CAROLINA,
CHAPEL HILL, N. C.

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EXPLANATION OF PLATE 64

Fig. 1. In the heart of Strowd's lowgrounds in winter. Haunt of the Wood Duck, Red-bellied Woodpecker, Red-winged Blackbird, Song and Swamp Sparrow, and many others. Photograph by Odum.

Fig. 2. Wood Thrush, nest and young in a Dogwood. Photograph by Odum.

Fig. 3. Woods in spring on Brierbridge Lane; dogwoods blooming, pines and oaks. The haunt of many woodland species and a favorite stop-over for transients. Photograph by Odum.

Fig. 4. View across University Lake, a 210-acre artificial lake with a 8½ mile shore line. Photograph by Coker.

Fig. 5. Carolina Chickadee and White-breasted Nuthatch at feeding station in winter. A good type of window feeding station supplying suet (in cage) and cracked nuts (on shelf). Photograph by Odum.

Fig. 6. The Mother Tanager eats in style. Eugene Odum's tame wild female Summer Tanager which had the remarkable record of returning for five summers (1928–1933). Photograph by Odum.

PLATE 64

1

2

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6

SPECIATION IN STENIRIDIA, A GROUP OF CYCHRINE BEETLES (FAMILY CARABIDAE, GENUS SCAPHINOTUS)

By J. M. Valentine

Plates 65–73

The species comprising the subgenus *Steniridia*, Casey, are typically highland-inhabiting forms restricted to the moist, deciduous and coniferous forests of the Appalachian uplift south of the line of southernmost glaciation. Their range is roughly delimited by the Ohio and Potomac Rivers on the north and by the five hundred foot contour line on the south and east. Their western extension into Kentucky and Tennessee has not definitely been determined. In numbers both of individuals and of species, the group is most abundantly represented in the higher mountain masses, preferring an altitude of three thousand feet or more. However, at least three species may have in the past descended river valleys for these forms are now found thriving in much lower altitudes along the Potomac and Ohio Rivers and on the North Carolina and Alabama piedmont. In these cases, the insects occur in the upland type of stream-side forest rather than in that characteristic of the flood plains.

The evolution of *Steniridia* into species follows a course parallel to speciation in other flightless, essentially non-migratory, mountain-dwelling beetles. Differentiation can be directly correlated with isolation, the more complete the latter, the more fundamental the dichotomy. Seven species in all are recognized herein. Of these, four (*andrewsi*, *violacea*, *guyoti* and *ridingsi*) are of the stem species type with relatively wide, overlapping ranges over which numerous geographic races or subspecies can be found. Living with these stem species, but occupying very limited areas, are two closely related species (*aeneicollis* and *tricarinata*), evidently isolation products. A single species (*lodingi*) represents a third category—that of an isolated form living out of contact with any other member of the group (Pl. 65).

The ability of the above-mentioned forms to retain their distinctiveness in spite of their association in identical ecological frames is taken as indication that they must be considered true species in the biological sense of the word. There is no evidence at present that they will hy-

bridize under natural conditions and a great deal of evidence, supplied by the *aedeagus* and its internal chitinizations, exists to support the theory that they are anatomically prevented from so doing even in event of inter-specific copulation. However, as with other organisms in nature, there probably resides in this specificity also a psycho-physiological reluctance to hybridize which may conceivably act as a potent isolation factor and thus become a cause as well as an end-product of morphogenesis.

Successful insemination depends, of course, upon the perfection of the probable lock-and-key-like relation of the genitalic elements of both sexes. The soft, everted *internal sac* of the male, bearing a more or less heavily chitinized, tongue- or spout-shaped piece, the *transfer apparatus*, at its distal extremity (Pl. 71, figs. 1–3), must be properly received by the vaginal cavity of the female so that the transfer piece reaches and fits a softer, horse-shoe-shaped organ, the *annulus*, situated on the ventral vaginal wall just posterior to the mouth of the *oviduct*. Sperm escape through the trough of the transfer apparatus and pass into the *seminal receptacle*, a cleft-like storage pocket formed by the walls of the annulus (Pl. 70, figs. 1–3). As the degree of development of this annulus seems to be in direct proportion to the extent of chitinization of the transfer apparatus, it is highly probable that the two structures interlock during coitus. Certainly their relative positions lead one to expect this.

Such a complex relationship does not lend itself to great deviation from the species standard. The internal sac and the vaginal cavity must be precise complements; any drastic departure from type, on the part of either sex, would almost certainly result in abortive or imperfect insemination. So it is not surprising to find that the structure of the male transfer piece in a given species is very constant, while differences between species in this respect are trenchant and are of a qualitative rather than a quantitative nature. On purely mechanical grounds alone, such a selective factor as the transfer piece seems quite sufficient to account for the breeding true of even closely related species of *Steniridia* when in ecological association.

With this diagnostic, internal structure are correlated less easily recognized, but taxonomically useful, external specific characters; chief among these is a secondary sexual one—the modification of the male front tarsus.

Geographic races or subspecies of *Steniridia*, on the other hand, depart from their respective stem stocks by essentially quantitative steps as

compared with species differences. The transfer piece may be a little longer or broader or thicker but its original plan remains unchanged. Much more obvious changes may occur externally in size, contour, sculpture and color, but even these seem to reflect the intensification of a few traits already obvious rather than the subtle, though often slight, remodeling of the whole organism as seen when genitalically distinct species are compared. It is true that species and subspecies are relative terms; however it is quite clear that they represent separate levels of the same biological phenomenon and as such possess a definite and objective value.

A subspecies or geographic race is a population spacially separated from its parent stock or closest relative and exhibiting a mean morphogenic departure of such a low order as not to preclude crossing with the related race at the zone of contact.

Once the subspecific or secondary differential level of any group has been determined by comparison with the first-order or specific level and checked by a study of transitional forms, it is not impossible to continue the analysis deductively. Thus, specific rank may be ascribed to forms which exhibit first-order differences but which cannot be proved to breed true in nature for the simple reason that they are geographically or ecologically remote from their closest kin. Similarly, subspecific rank may be deductively assigned to forms whose connecting link with the mother colony is unknown or which are so remotely isolated from their relatives as to have lost all connection. These problems can be settled more or less satisfactorily, in *Steniridia* at least, by referring the forms in question to specific standards previously established, bearing in mind that apparent isolation is no proof either of specificity or subspecificity but that ecological association with the stock genetically closest is the best field evidence for specificity provided the points of difference include the genitalia and are of the first-order magnitude.

Under the term "variety" is included all those color phases and aberrant individuals sufficiently distinct to merit the retention of specific and subspecific names wrongly applied. These are not geographical or ecological populations—merely extreme variants within the mother colony. It is important, in this regard, to note that in all such cases considered, the aedeagi are absolutely characteristic of the parent stock and do not share in the conspicuous alterations of external contour, etc.

The above systematic criteria are used in the present synopsis of *Steniridia* in order to lend greater biological significance to the various names already in use and to stimulate the dissection and detailed study

of genitalic structures prior to future publication in this and other groups of carabids.

Especial acknowledgment is due Mr. Herbert S. Barber of the Department of Agriculture for his keen and helpful interest in this work and for his assistance, generously bestowed, in making preparations. To Dr. Edward A. Chapin and Mr. L. L. Buchanan of the National Museum the author is greatly indebted for the loan of specimens and for the privilege of dissecting the Casey types of *Steniridia*. Mr. P. J. Darlington, Jr. has very kindly consented to the loan of important material from the Museum of Comparative Zoology and from his private collection; through his courtesy the author was enabled to study and dissect the unique type of *violacea* in the Leconte collection. The following have greatly assisted the author by generously contributing valuable material for dissection and study: Dr. Henry P. Löding, Mr. E. T. Cresson, Jr., Mr. J. Mutchler, Dr. J. Chester Bradley, and Prof. David Dunavan. In Mr. Mutchler's absence, Dr. C. H. Curran most kindly extended the author the privilege of working with the collections in the American Museum. To Mr. Lane Barksdale and to Messrs. Joseph R. and Reeve Bailey, the author extends his sincere thanks for collecting for him important material in the mountains of North Carolina and Tennessee.

METHODS

Dissections of the genitalia of both sexes were made in Barber's relaxing fluid[1] after soaking the insect in this mixture for ten minutes or longer. The internal sac of the male was extracted through a lateral, longitudinal incision in the *median lobe* (penis), the connection between the sac and the apical end of the lobe remaining intact. After lifting out the basal portion of the sac with its afferential duct, the transfer piece, visible through the folds of the internal sac as a dark mass, was carefully dissected out. The inflation of the internal sac is perhaps a better method of exhibiting its chitinizations than the dissection of the median lobe; certainly the functional shape of the sac cannot otherwise be properly observed. However, unless great skill is employed, this operation more often than not results in damage or failure. Mr. H. S. Barber, using a micro-injection pipette, has achieved noteworthy results (Pl. 71, figs. 1–3); he prepared the aedeagus for inflation by soaking

[1] Barber's relaxing fluid: 95 per cent alcohol, 265 parts; water, 245 parts; ethyl acetate, 95 parts; benzol (benzene), 35 parts.

it in weak caustic potash and assisted the process of evagination by gently pulling the sac out of its sheath by means of a hooked needle. Meanwhile, hydrostatic pressure was applied at the basal orifice of the median lobe. To preserve the sac in its distended position, hardening agents such as strong alcohol followed by xylol may be necessary.

All measurements were made with the aid of a micrometer eye-piece graduated to tenths of millimeters. Curved surfaces were measured as the chords of those surfaces between the desired limits. As traits of contour and proportion cannot be expressed by linear measurements, an attempt was made to describe such with the aid of indices. Principal ratios were obtained in the following manner:

(1) *Head index*: The distance across the eyes (width), measured dorsally from their outer margins, divided by the distance from the outermost extremity of the mandibles in parallel position, to the anterior margin of the pronotum when the head is parallel to the latter (length).

(2) *Pronotal index:* The distance from the anterior to the posterior extremities of the pronotal margins measured in the mid-dorsal line (length) divided by the greatest transverse distance across the pronotum (width).

(3) *Elytral index:* The greatest transverse distance across the elytra (width) divided by the distance, measured along the suture, from the furthermost elytral apex to the posterior margin or apex of the scutellum (length).

(4) *Abdominal index:* The deepest measurement of the abdomen plus the elytra (height) divided by the elytral length; the former was taken, after bending the rear leg dorsally at the coxal joint, by optically placing one end of the scale on the level of the intercoxal metasternum and reading the level of the most elevated portion of the elytral suture when the longitudinal axis of the insect was oriented roughly at right angles to the scale.

(5) *Tarsal index:* The total length of the squamous pad borne on the plantar surface of the first (longest) segment of the male tarsus divided by the total length of this segment measured along the same surface.

The *total length* was obtained by adding head length, pronotal length, scutellum and elytral length, care being taken to see that the insect was closely articulated before measurement.

All illustrations are original. The photographs were taken on panatomic film. The drawings were outlined with a camera lucida.

Genus SCAPHINOTUS Dej.

Dejean: Spécies Général des Coléoptères, vol. 2, p. 17, 1826, Latreille's *Scaphinote*, 1822 and 1825, not being latinized, is invalid according to article 3 of International Rules of Zoological Nomenclature, 1926.

Genotype: elevatus Fabricius, Mantissa Insectorum, vol 1, p. 198, 1787.

This category is herein used in its narrow sense as a genus. It includes those deeply striate, pigmented forms having simple, undilated cheeks, heavily punctate elytral epipleura and a maximum of two pronotal marginal setae on either side. It is not within the scope of the present paper to analyze generically the various groups into which *Scaphinotus* in its broader sense might be divided. However for the sake of rendering a clearer picture of the evolution and distribution of this American supergenus, it is necessary to elevate to generic rank most of the categories which are now generally considered subgenera (Van Dyke, Csiki, etc.). Thus, in eastern North America, the multisetose *Nomaretus* of Ozarkian origin and the astriate, depigmented *Maronetus* of the southern Appalachians, both with modified cheeks, had best be treated as genera.

Scaphinotus, as defined above, contains three natural groups, treated here as subgenera: *Scaphinotus* s. str., *Irichroa* Newman, and *Steniridia* Casey. These possess anatomical features and ranges sufficiently characteristic to warrant their taxonomic separation. The following key is intended to bring out these differences and is applicable at least to eastern North American species of *Scaphinotus*:

I. Pronotum with wide, strongly reflexed margins. Internal sac of male chitinized throughout; transfer apparatus not or weakly differentiated, transitional with the folds of the internal sac. Widely ranging, lowland-inhabiting species as well as highland-dwelling species with restricted ranges.

A. Pronotum asetose or unisetose, margins very wide; humeral margins wide, reflexed. Internal sac in situ with conspicuous longitudinal fold or crest along membranous wall of aedeagus. The southwestern Rocky Mountains (U. S. and Mexico) ranging north and east into the Mississippi, Gulf and Atlantic lowlands A. *Scaphinotus* (14 species)

AA. Pronotum bisetose, margins relatively narrow; humeral margins normal. Internal sac without median crest. The entire Appalachian highlands ranging from the northern portion south into the Atlantic and Gulf coastal regions AA. *Irichroa* (1 species—*vidua*)

II. Pronotum with normal or narrow margins. Internal sac without median crest, very weakly sclerotized except for transfer apparatus, which is usually strongly reinforced with chitin, and a pair of sclerotized folds situated more proximally. Typically highland-inhabiting species of the southern Appalachians.....*Steniridia* (7 species)

Subgenus SCAPHINOTUS s. str.

Genotype: elevatus Fab.

Subgenus IRICHROA Newman

Newman: Entomological Notes. Ent. Mag., vol. 5, p. 385, 1838.
Genotype: vidua Dejean, Spécies Général des Coléoptères, vol. II, p. 12, 1826.

Subgenus STENIRIDIA Casey

Casey: Additions to Coleoptera. Mem. Coleop., vol. 11, p. 236, 1924.
Genotype: andrewsi Harris, Remarks on *Cychrus*. Bost. Jour. N. Hist., vol. 2, no. 2, 1839.

Diagnosis: medium to large forms (15–30 mm.) strongly convex, usually violaceous or aeneous, with relatively large head, long jaws and appendages, small cordate or conical pronotum bearing two setae on either side and with normal margination.

Casey at first (1920) retained *andrewsi* and its relatives under the genus *Irichroa* after erecting the genus *Megaliridia* for *vidua*. However, it was pointed out to him by Leng that *vidua* is the genotype of *Irichroa*; consequently he suppressed (1924) *Megaliridia* and established the genus *Steniridia* to contain the *andrewsi* group.

Thomas Casey's primary interest lay in the description of external contour and other habitus characters. Since members of the group *Steniridia* are exceedingly variable in this respect, it is not surprising that his work should result in the addition of a large number of specific names. In several instances, unit populations were divided by him into a series of component species while one of his subspecies (*tricarinata*) appears to be fundamentally (specifically) distinct from its supposed close relative (*aeneicollis*). Yet his work is of great value as it is a careful classification of the principal forms a species may assume in a given locality. His view-point is the logical outcome of the quantitative method of taxonomic analysis based upon external differences. It must be admitted that this contrasts strongly with the biological approach which

aims to discover similarities as well as differences and these of a nature as fundamental as possible.

The seven species contained in *Steniridia* are keyed below:

I. Plantar pad on the first segment of male tarsus more than one half the total length of the first segment (tarsal index 0.51–0.82) (excepting *ridingsi intermedia*, tarsal index 0.50).
  A. Size relatively large; if smaller than 23 mm. elytral costae interrupted and confluent on the marginal and posterior disc.
    B. Median lobe of aedeagus normal, with conspicuous spoon-shaped transfer apparatus heavily chitinized as a separate piece.
      C. Pronotum much constricted posteriorly; median lobe of aedeagus with quadrate transfer apparatus bearing on its convex surface, a median, longitudinal carina *aeneicollis* (Pl. 71, figs. 1–5)
      CC. Pronotum normal; median lobe with elongated, spatulate transfer apparatus bearing no median carina *andrewsi* (Pl. 72, fig. 9; Pl. 73, figs. 1–9)
    BB. Median lobe of aedeagus elongate, with complex, folded, lightly chitinized transfer apparatus integral with the walls of the internal sac..... *tricarinata* (Pl. 71, figs. 6–7)
  AA. Size relatively small (16–20 mm.); elytral costae not confluent; aedeagus without heavily chitinized transfer apparatus *ridingsi* (Pl. 72, figs. 6–8)
II. Plantar pad on the first segment of male tarsus less than one half but greater than one third the total length of the first segment (tarsal index 0.40–0.48); median lobe of aedeagus more arcuate than in *andrewsi*, transfer apparatus discrete, tongue-shaped, bearing on its convex surface, three, deep, longitudinal carinae—one median and two lateral..... *violacea* (Pl. 71, figs. 8–10)
III. Plantar pad on the first segment of male tarsus one third or less than one third the total length of the first segment (tarsal index 0.21–0.36).
  A. Very convex forms (abdominal index 0.42–0.50) with confluent elytral costae; median lobe of aedeagus elongated, much constricted in basal half; transfer apparatus folded, complex, lightly chitinized, integral with walls of internal sac *guyoti* (Pl. 72, figs. 1–3)
  AA. Much flattened forms (abdominal index 0.38–0.46) with cordate elytra and entire elytral costae; median lobe of aedeagus only slightly constricted near base, transfer apparatus small, discrete, heavily chitinized, deeply flanged and carinate *lodingi* (Pl. 72, figs. 4–5)

DESCRIPTIONS

For the sake of brevity and clarity, synonymy has been omitted except where it involves a name under immediate consideration. De-

tailed descriptions not of a comparative nature have also been omitted. The worker is referred to original descriptions and to Roeschke's monograph of the *Cychrini* (see bibliography) for these matters. The diagnostic characters are given in the key.

Total length is indicated by L. and elytral width by W. The indices, defined above, are abbreviated in the following manner: h. ind.—head index; p. ind.—pronotal index; e. ind.—elytral index; a. ind.—abdominal index; t. ind.—tarsal index of male.

Specimens recorded by others but not actually studied by the author are not included in this paper. Over the past three years, an effort has been made to collect in as many localities in the southern Appalachians as possible and to examine all the *Steniridia* material of the larger museums. Since a great many samples have been examined, the author feels that he can afford to overlook unverified records and thus avoid a source of taxonomic error.

1. **Steniridia andrewsi** Harris

This stem species is the widest ranging of the group; its various races extend unbrokenly along the Appalachian chain from southern Pennsylvania to northern Georgia while local populations are found sporadically on the piedmont and along the Ohio drainage system.

In general the larger, more brilliant and less deeply sculptured races occur in the lowland and become progressively smaller, blacker and more irregularly pitted in the higher altitudes. The same phenomenon is observable in other species.

1a. *S. andrewsi* s. str. Harris

Harris, T. W.: Remarks on *Cychrus*. Bost. Jour. Nat. Hist., vol. 2, no. 2, 1839.

Type: ♀, not in the Harris collection in the Boston Museum; evidently lost.

Type locality: "North Carolina."

Neotype ♀: U. S. National Museum. J. M. Valentine, collector.

Neotype locality: Chapel Hill, Orange Co., North Carolina. (Pl. 65.)

Neotype ♀: L. 23.9 mm.; W. 9.4 mm.; h. ind. 0.44; p. ind. 0.89; e. ind. 0.70; a. ind. 0.44. Above, head and pronotum green-blue-black, elytra deep, brilliant, violaceous blue with greener margins; below, black, except for purplish black elytral epipleurae and yellowish brown tarsi.

Neotopotypes: 2♂s (one imperfect): L. 23.0 mm.; W. 8.8 mm.; p. ind.

0.83–0.85; e. ind. 0.70–0.71; a. ind. 0.42–0.46; t. ind. 0.53. Above, deep, rather brilliant violaceous; head blacker with green reflections; below, as in neotype (Pl. 67, fig. 2).

♀ : L. 24.2 mm.; W. 9.2 mm.; h. ind. 0.41; p. ind. 0.91; e. ind. 0.67; a. ind. 0.47. Darker violaceous than male, head blue-green-black, elytra and pronotum with blue-green reflections, especially on sides.

Harris' description of *andrewsi* (from "manuscript catalog of Prof. Hentz") agrees with this lowland form and not with the more western, highland race (*montana* subsp. n.) inasmuch as the tarsi of the former are "rust-colored," the pronotum sides cordately "rounded," and the elytral striae and costae are interrupted only at the "tip." This race is of a deeper, more brilliant blue or violet, is more convex, has narrower reflexed margins throughout and has a pronotal base which is more profusely punctate than *montana*. These characters, though admittedly relative, are convincingly indicated by Harris. The elytral striae are not quite so broadly punctate as in *montana* and the irregularities in apical sculpture are more posteriorly confined. The squamous pad on the first segment of the male front tarsus extends a little more than half way to the segment's base (Pl. 69, fig. 3). The transfer apparatus of the median lobe of the aedeagus is shorter and wider than in other races of *andrewsi*; viewed from above, it has the shape of the sole of a shoe (Pl. 73, figs. 6–7).

Another reason for selecting the piedmont race of *andrewsi* as neotypical is the reference made by Harris to the source of material. He says: "Prof. Hentz" (at the University of North Carolina, Chapel Hill, N. C., 1826–30) . . . "dedicated this species to its discoverer, the son . . . of Prof. Andrews, late of the University of North Carolina." In all probability this is a lost species originally taken at Chapel Hill and only rediscovered some three years ago by the author.

Chorology: Under logs in oak-pine-dogwood-hickory woods along banks of woodland streams. To the author's knowledge, *andrewsi* has been found on the piedmont only at Chapel Hill where it occurs sparingly during June and October.

1b. *S. andrewsi montana* subsp. n.

Type: ♂, U. S. National Museum. J. M. Valentine, collector.
Allotype: ♀, U. S. National Museum. J. M. Valentine, collector.
Type locality: Beech Mountain, Avery Co., North Carolina (Pl. 65).

Type ♂: L. 21.4 mm.; W. 8.5 mm.; h. ind. 0.42; p. ind. 0.83; e. ind. 0.73; a. ind. 0.44; t. ind. 0.77. Above, violaceous, head and pronotum with blue reflections; below, black, elytral epipleurae slightly purplish; tarsi very dark brown (Pl. 66, fig. 1).

Allotype ♀: L. 23.4 mm.; W. 9.3 mm.; h. ind. 0.46; p. ind. 0.83; e. ind. 0.75; a. ind. 0.48. Green-blue-black with violet reflections.

Paratypes: 2♂s: L. 19.8–20.2 mm.; W. 7.6–8.2 mm.; h. ind. 0.42–0.44; p. ind. 0.83–0.85; e. ind. 0.72–0.74; a. ind. 0.47; t. ind. 0.70–0.82. Violaceous, head and pronotum with green-blue reflections.

♀: L. 23.8 mm.; W. 9.3 mm.; h. ind. 0.45; p. ind. 0.81; e. ind. 0.69; a. ind. 0.45. Color as in males.

This race is the form commonly referred to typical *andrewsi*. It differs, however, in the pronotum whose margins are wider and straighter posterior to the lateral angle which is more pronounced; in the pronotal base which is less densely punctate, sometimes almost impunctate; in the punctures of the elytral striae which are more conspicuous and produce posterior irregularities in the costae, especially along the sides, half way to the elytral base; and in the more profusely and irregularly punctate elytral epipleurae. The tarsi are almost black, are more dilated in the male and are unique in *Steniridia* in having the first segment in the male almost fully scaled beneath (Pl. 69, fig. 1).

Chorology: This race is relatively abundant, in its typical form, on the mountain sides and in the valleys of the high ranges of northwestern North Carolina south probably to where the French Broad River separates the northern from the southern Carolina highlands. It should be looked for where the high Carolina range extends into Virginia in the neighborhood of White Top Mt., Grayson Co. On Mt. Guyot, in the more southerly Smokies, *andrewsi* seems to be intermediate between *montana* and a still more southerly race, *parvitarsalis* subsp. n. (Pl. 65; Pl. 69, fig. 7).

Type and allotype: under bark of log on south side of Beech Mountain, Banner Elk, N. C., about 5000 ft., in beech-birch-chestnut association bordering a small stream, late August, 1934. Paratypes: five males, one female, in molasses traps set in moist, rocky ravine among rhododendron and large hemlocks, 3500 ft., Banner Elk, N. C., Sept., 1934. Collector, J. M. Valentine.

Material from the following localities is essentially similar: Grandfather Mountain, Avery Co., N. C.; Little Switzerland, Dowell Co., N. C.; Mt. Mitchell, Buncombe and Yancey Cos., N. C.

Synonymy: 1b′. *S. andrewsi montana* var. *amplicollis* Casey

Casey, T. L.: Mem. Coleop., vol. 9, p. 174, 1920.
Type: ♂, U. S. National Museum. Beutenmüller, collector.
Type locality: "Black Mts., N. C."
Type ♂*:* L. 23 mm.; W. 8.8 mm.; h. ind. 0.45; p. ind. 0.78; e. ind. 0.68; a. ind. 0.42; t. ind. 0.715. Violaceous above (Pl. 66, fig. 2).

This is merely a broadly margined individual of *montana* and is not typical of the locality as indicated. It has been given varietal recognition by the author because it represents an extreme variant. Genitalically, it is precisely similar to *montana*. Casey was definitely in error when referring it subspecifically to *violacea;* it bears no relation to this species. A "paratype" female is intermediate between *amplicollis* and typical *montana*.

The form described by Casey as *andrewsi* subsp. *refleza* from a single female ("Black Mts., N. C." Beutenmüller, U. S. National Museum) is a less extreme variant of *montana*, having slightly more reflexed, straighter pronotal margins. Genitalically, it is identical with the latter.

1c. *S. andrewsi germari* Chaudoir

Chaudoir, Baron M. de: Bull. Soc. Nat. Moscow, vol. 34, p. 5, 1861.
Type: ♀, location unknown.
Type locality: "Tennessee."

Germari presents quite a different habitus from *montana* with which race it is in closest geographical association. It is generally larger, more elongate and possesses a pronotum which is very characteristic, being long (sometimes as long as wide), narrow, straightsided, deeply impressed basally and often sculptured with fine transverse wrinkles and dense basal punctures. The aedeagus of the male, however, does not differ to any appreciable extent from that of race *montana* and seems to be consistent over the wide range which *germari* occupies (Pl. 73, figs. 1–5). The front tarsi of the male are dilated as in *montana* but the scaly pad of the first segment is more limited longitudinally; however, this character is unstable as evinced by variation in the colony at Uniontown, Pa. (Pl. 69, fig. 2).

Uniontown, Pa. (extreme variants selected from a large series): 7 ♂s: L. 23.6–20.7 mm.; W. 8.2–9.0 mm.; h. ind. 0.43–0.48; p. ind. 0.88–0.97; e. ind. 0.69–0.72; a. ind. 0.41–0.44; t. ind. 0.60–0.69. Head green-

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blue-black with violaceous reflections, pronotum violaceous with green-blue reflections, elytra violaceous often with aeneous reflections; sometimes insect almost black with slight purplish tint; below, as in *montana*.

4 ♀s: L. 24.2–26.9 mm.; W. 9.2–10.7 mm.; h. ind. 0.45–0.44; p. ind. 0.90–1.02; e. ind. 0.68–0.70; a. ind. 0.43. Color as in male.

Cincinnati, Ohio: 4 ♀s: L. 23.0–26.0 mm.; W. 9.5–10.7 mm.; p. ind. 0.93–0.96; e. ind. 0.71–0.73; a. ind. 0.44–0.46. Violaceous with green-blue or aeneous reflections.

Pennington Gap, Va.: 2 ♂s: L. 22.5–23.2 mm.; W. 8.8–9.1 mm.; h. ind. 0.41–0.43; p. ind. 0.88–0.93; e. ind. 0.72–0.76; a. ind. 0.43–0.46; t. ind. 0.53. Violaceous, head and pronotum darker, with blue-green reflections.

2 ♀s: L. 24.1–25.6 mm.; W. 10.2–9.3 mm.; h. ind. 0.42–0.45; p. ind. 0.88–0.98; e. ind. 0.70–0.72; a. ind. 0.46. Color same as in males.

Mountain Lake, Va.: 3 ♂s: L. 19.2–21.8; W. 7.3–8.2; h. ind. 0.41–0.46; p. ind. 0.86–0.90; e. ind. 0.68–70; a. ind. 0.42–0.45; t. ind. 0.70–0.77. Violaceous with green-blue reflections on darker head and pronotum.

3 ♀s: L. 23.2–24.0 mm.; W. 9.1–9.4 mm.; h. ind. 0.43–0.44; p. ind. 0.86–0.91; e. ind. 0.69–0.70; a. ind. 0.44–0.47. Color as in males excepting one very much darker green-blue specimen from the open mountain top.

Chorology: This is the widest ranging form of all *Steniridia*. It seems to have adapted itself to lowlands as well as high altitudes but is characteristic of the great plateau, averaging 1500 ft., which stretches from southwestern Pennsylvania in a southwesterly direction across eastern West Virginia and western Virginia and breaks up in northeastern Tennessee, the probable type locality (Claiborne Co.). The New River, cutting across the mountain plateau at right angles, evidently is no barrier to the dispersal of this form since the insect is found on both sides and follows it, as well as the upper reaches of the Ohio, westward as far as Cincinnati. Where the higher, more eastern mountain mass of North Carolina merges with the Virginia plateau, a smaller form of *germari* is found at high altitudes (4000 ft.) which is clearly intermediate between this race and the more restricted *montana* (Mountain Lake, Giles Co., Va.). The following locality records are at hand: Uniontown, Fayette Co., Pa.; Cincinnati, Hamilton Co., Ohio; Gawley Mt., Fayette Co., W. Va.; Fairmont, Marion Co., W. Va.; Pennington

Gap, Lee Co., Va.; Harlan, Bell and Whitley Cos., Ky.; Frankfort, Franklin Co., Ky. (Pl. 65).

Germari inhabits the same situations as *montana* which it entirely displaces over its range. Under bark and logs in moist, mixed, deciduous forests along mountain streams is its favorite haunt. Like nearly all members of the group, it is most abundant in June and September. It is unquestionably the most frequently collected *Steniridia*, but this fact may simply reflect a wide range rather than abundance.

Synonymy: Slight variants within the colony at Uniontown, Pa., have been described by Casey (1920) as a species (*"mutabilis"*) and two subspecies (*"mutabilis longicollis"* and *"m. modulata"*). The main point of difference lies in the slightly less elongated scaly pad on the first segment of the male front tarsus, a variable character. Size and contour differences were obtained by sorting sexes, *"mutabilis"* having a type series of five males, *"longicollis"* being represented by three large males and six females, and *"mutabilis"* being a unique male. The aedeagi were indistinguishable from typical *germari*.

1d. *S. andrewsi parvitarsalis* subsp. n.

Type: ♂, U. S. National museum.

Type locality: Clayton, Rabun Co., Georgia (Pl. 65).

Paratypes: 4♂s, Philadelphia Academy, U. S. National Museum, Cornell Univ., Ithaca, N. Y. 2♀s: Philadelphia Academy, Cornell Univ., Ithaca, N. Y.

Type ♂: L. 20.6 mm.; W. 8.5 mm.; h. ind. 0.46; p. ind. 0.86; e. ind. 0.73; a. ind. 0.48; t. ind. 0.61. Above, rather brilliant violaceous, head and pronotum darker with blue reflections; below, black, elytral epipleurae faintly purplish, tarsi yellowish brown.

Paratypes: 4♂s: L. 20.7–22.3 mm.; W. 8.4–8.8 mm.; h. ind. 0.42–0.46; p. ind. 0.82–0.90; e. ind. 0.70–0.72; a. ind. 0.46–0.48; t. ind. 0.60–0.67. Color as in type (Pl. 66, fig. 3; Pl. 69, fig. 5).

2♀s: L. 21.5–23.2 mm.; W. 8.7–9.3 mm.; h. ind. 0.43–0.46; p. ind. 0.86–0.90; e. ind. 0.71; a. ind. 0.48–0.50. Color as in type, a little bluer throughout.

Parvitarsalis is a distinct race superficially resembling *montana* but differing notably in the much less expanded front male tarsus whose first plantar pad is much reduced. It is this character which has led workers to misidentify specimens as *violacea* Lec. *Violacea* posesses

genitalic features which clearly separate it from *parvitarsalis*; the latter is barely distinguishable, genitalically, from *montana* and *germari* (Pl. 73, figs. 8–9). Even in the female genital system, specific characters trenchantly intervene between *violacea* and *parvitarsalis* (Pl. 70, figs. 1–2). In color, *parvitarsalis* from its type locality is more brilliantly violaceous than *montana* from which it differs also in having yellowish brown tarsi, a more elongate pronotum with wider margins more concave posterior to the lateral angle, and an irregularly punctate pronotal base. In addition, irregularity in elytral striae is confined to the extreme margin and to the apical third of the elytra.

Specimens from the Nantahala range, North Carolina, which resemble closely a series from the "Blue Ridge Mts., N. C.", collected by Gustav Beyer, are somewhat smaller, darker and show a tendency for costal interruption characteristic of *montana*. A similar form has been taken by F. R. Mason in the southern Unaka Mountains of Tennessee. These have the following characteristics:

Nantahala Mts., N. C.: 3♂s: L. 17.3–20.0 mm.; W. 7.6–8.1 mm.; h. ind. 0.44–0.48; p. ind. 0.80–0.83; e. ind. 0.72–0.81; a. ind. 0.43–0.47; t. ind. 0.64–0.69. Dark violaceous (Pl. 69, fig. 6).

♀: L. 20.4 mm.; W. 8.0 mm.; h. ind. 0.43; p. ind. 0.87; e. ind. 0.71; a. ind. 0.46. Color as in males.

Unaka Mts., Tenn.: ♂: L. 21.2 mm.; W. 8.0 mm.; h. ind. 0.47; p. ind. 0.85; e. ind. 0.70; a. ind. 0.46; t. ind. 0.61. Violaceous with aeneous reflections (Pl. 69, fig. 4).

Chorology: Parvitarsalis is typically a form of the low mountains (2000–3000 ft.) of northeastern Georgia where it represents *andrewsi*. However, subraces occur in the higher altitudes (3000–4000 ft.) of those connecting ranges of the southern Blue Ridge of North Carolina which run in a northwest-southeast direction between the forks of the Little Tennessee and the Hiawassee Rivers. *Parvitarsalis* is limited on the northeast and southwest by these streams and on the west by the abrupt drop in altitude at the Tennessee line where the southern Unaka Mts. are located. In the last-named, another subrace occurs which intergrades with *montana* in the Smokies.

The following locality records are at hand: Clayton (type), Satola (paratype), Mountain City (paratypes), all in Rabun Co., Ga.; Grimshawes, Jackson Co., N. C.; Unaka Mts., Monroe Co., Tenn., 3500 ft. (Pl. 65).

In habits, *parvitarsalis* resembles *montana* and *germari*.

1e. *S. andrewsi darlingtoni* subsp. n.

Type: ♂, Museum of Comparative Zoology. P. J. Darlington, collector.

Allotype: ♀, Museum of Comparative Zoology. P. J. Darlington, collector.

Paratype: ♂, Museum of Comparative Zoology. P. J. Darlington, collector.

Type locality: Newfound Gap, Sevier Co., Tenn., 3500 ft.

Type ♂: L. 19.7 mm.; W. 7.4 mm.; h. ind. 0.47; p. ind. 0.81; e. ind. 0.61; a. ind. 0.43; t. ind. 0.62. Above, dark violaceous, margins and head with green-blue reflections; below, black, elytral epipleurae violaceous black, front tarsi dark yellowish brown (Pl. 66, fig. 4).

Allotype ♀: L. 20.8 mm.; W. 8.0 mm.; h. ind. 0.43; p. ind. 0.78; e. ind. 0.68; a. ind. 0.46. Color similar to type, darker, blue-green reflections on disc.

Paratype ♂: L. 16.8 mm.; W. 6.5 mm.; h. ind. 0.48; p. ind. 0.82; e. ind. 0.64; a. ind. 0.44; t. ind. 0.70. Very dark violaceous, disc with dull green reflections.

This race of *andrewsi* includes the smallest specimens the author has seen. It is much more elongate than *montana* or *parvitarsalis* and is conspicuously different in having reduced humeri. The elytral punctures are larger and more irregular and the pronotal base is rugosely punctate. The pronotal sides are distinctly concave posterior to the well defined lateral angles, though not so much so as in typical *parvitarsalis*. The basal tarsal pad in the male is more extensive than in the latter (Pl. 69, fig. 8). The aedeagi are almost indistinguishable, except in size, from other monticolous *andrewsi*.

Chorology: The coarse sculpturing, dark coloration, and small size reflect the conditions of high altitude under which this colony exists. A specimen from lower down (Bryson City, 2000 ft.) is less sculptured and more transverse; it serves to connect *darlingtoni* with its lowland relatives. *Darlingtoni* is undoubtedly a very localized form; it ascends to moisture-laden regions at elevations greater than those occupied by any other race of *andrewsi* so far examined, and it seems to be restricted to the heavily forested Smoky Mountain ridge and adjacent ravines in the region of Mt. Leconte. The following labels are carried by the type series: "State Road to Newfound Gap," Sevier Co.; "Tenn., 3500 ft." (type and allotype); "Newfound Gap to Clingman's Dome, Tenn.—N. C., 5000 ft." (paratype); "Bryson City," Swain Co.; "N. C., 2000 ft."

These specimens were all collected by P. J. Darlington, Jr., after whom it is a pleasure to name the subspecies.

1f. *S. andrewsi waldensia* subsp. n.

Type: ♂, Philadelphia Academy, H. A. Pilsbry, collector.
Allotype: ♀, Philadelphia Academy, H. A. Pilsbry, collector.
Type locality: Sawyer's Springs, Tennessee.

Type ♂: L. 25 mm.; W. 10.2 mm.; h. ind. 0.45; p. ind. 0.81; e. ind. 0.72; a. ind. 0.44; t. ind. 0.47. Above, rather brilliant violaceous, head blue-green-black, margins green blue; below, black, tarsi dark brown (Pl. 67, fig. 1).

Allotype ♀: L. 28.4 mm.; W. 10.9 mm.; h. ind. 0.42; p. ind. 0.83; e. ind. 0.70; a. ind. 0.61. Color as in type, pronotum darker, greener.

Judging by its general habitus, *waldensia* is a giant relative of *parvitarsalis*; the pronotum posterior to the lateral angles is similarly elongated and the male tarsal pad (Pl. 69, fig. 9) on the first segment is similarly reduced. The elytral striae are relatively finely and evenly punctured, there being very little costal interruption except at the extreme elytral apex. The base and margins of the pronotum are shallowly, irregularly punctate. The elytral epipleurae are more finely, regularly punctate than usual. The aedeagus is typical of the western races of *andrewsi*.

Chorology: All external features—size, color and sculpture, combine to place the habitat of this race in the relatively low mountains or actual piedmont. The only two specimens seen came from Walden Ridge, Hamilton Co., Tennessee, just north of Chattanooga. It is fitting that this insect should bear the name of the isolated ridge where such a unique race could have easily been evolved (Pl. 65).

2. **Steniridia violacea** Leconte

Often confused with various races of *andrewsi*, this species can best be identified by dissecting the genitalia of either sex (Pl. 70, fig. 2; Pl. 71, figs. 8–10). The characters of the aedeagi which separate *violacea* from *andrewsi* its nearest relative have been described in the key; they are both constant and easily recognized. Apart from this means of identification, the very much reduced plantar pad of the first segment of the male front tarsus affords the best external clue. In habitus, *violacea* differs from *andrewsi* in being shorter and more convex, in having wider, less abruptly reflexed pronotal margins, in possessing elytral

punctures which are coarser, embracing more of the walls of the costae and giving to the elytra a beaded appearance, and finally in having pronounced setigerous papillae on the humeral margins.

Chorology: The range of *violacea* is much that of *parvitarsalis*. However, insufficient material bearing accurate, detailed locality labels has been collected to map out the area covered by this species. From what is known of its habits, it frequents the same situations as *andrewsi*, being found in association with it at all altitudes attained by the latter.

2a. *S. violacea* s. str.

Leconte, J. L.: New Species of North American Coleoptera. Smith's Misc. Coll., vol. 6, no. 167, p. 4, 1863.

Type: ♂, Museum of Comparative Zoology.

Topotype: ♀, author's collection.

Type locality: "Mountains of Georgia."

Type ♂: L. 19.6 mm.; W. 7.8 mm.; h. ind. 0.53; p. ind. 0.73; e. ind. 0.72; a. ind. 0.47; t. ind. 0.42. Rather dark violaceous, pronotum blue with violet reflections, elytra with slight blue reflections (Pl. 67, fig. 3; Pl. 69, fig. 12).

Topotype ♀: L. 22.9 mm.; W. 9.4 mm.; h. ind. 0.50; p. ind. 0.73; e. ind. 0.73; a. ind. 0.46. Above, dark violaceous, slightly blue on margins, head with blue reflections; below, black, tarsi dark brown.

Two large females from the Smoky Mountains gave the following measurements: L. 22.1–23.2 mm.; W. 9.1–9.3 mm.; p. ind. 0.76; e. ind. 0.71–0.74; a. ind. 0.48. Violaceous with slight aeneous reflections, margins green-blue.

Chorology: Although the exact locality of the type *violacea* is not known, Tray Mountain, marking the convergence of three counties (Town, White, Habersham), is centrally situated in the restricted mountainous area of north Georgia and therefore cannot be far from the true type locality. Leconte once lived in this section. The "topotype" was collected by molasses trap in September on the summit of Tray Mt. (4400 ft.) on a rocky slope among small oaks and chestnuts (Pl. 65).

The Smoky Mountains specimens (Bryson City, Swain Co., N. C., 2000 ft., Darlington) possibly represent a new race. This, however, cannot be determined until males are taken (Pl. 65).

2b. *S. andrewsi violacea carolinae* subsp. n.

Type: ♂, U. S. National Museum. G. Beyer, collector.

Allotype: ♀, U. S. National Museum.

Paratypes: 4♂s, U. S. National Museum, American Museum, Philadelphia Academy; 4♀s, U. S. National Museum, American Museum, Philadelphia Academy.

Type locality: "Blue Ridge Mts., N. C."

Type ♂*:* L. 21.2 mm.; W. 5.75 mm.; h. ind. 0.47; p. ind. 0.91; e. ind. 0.73; a. ind. 0.51; t. ind. 0.47. Violaceous-black above, tarsi dark brown (Pl. 67, fig. 4).

Allotype ♀*:* L. 23.4 mm.; W. 9.6 mm.; h. ind. 0.49; p. ind. 0.77; e. ind. 0.74; a. ind. 0.49. Color as in type.

Paratypes: 4♂s: p. ind. 0.71–0.74; e. ind. 0.72–0.74; a. ind. 0.46–0.49; t. ind. 0.40–0.48. Violaceous-black with dark green reflections on the margins and sometimes on the disc (Pl. 69, fig. 13).

4♀s: p. ind. 0.73–0.74; e. ind. 0.70–0.74; a. ind. 0.46–0.50. Violaceous-black with slight green reflections on disc.

Carolinae is a race fairly distinct from the type in being darker, and in having more coarsely and irregularly punctate striae. The costae are interrupted marginally and discally as well as apically. The aedeagus differs slightly, the median lobe being more arcuate and the transfer piece having apically converging walls (Pl. 71, figs. 9–10).

Chorology: Gustav Beyer collected quite a large series of this form. His label—"Blue Ridge Mts., N. C.", is too embracing to allow of definite type locality determination. However, since Beutenmüller, who collected extensively in the Black Mts., and other collectors failed to find *violacea* there it is reasonable to suppose that this northern portion of the Blue Ridge does not contain it. Therefore the few specimens of Beyer's collecting labeled "Black Mts., N. C." are probably erroneously tagged. These have not been included in the type series; neither have those marked simply "N. C." The type locality has been tentatively placed in Transylvania Co., N. C., in the southern Blue Ridge where one would expect the range of *violacea* to extend (Pl. 65).

3. **Steniridia aeneicollis** Beutenmüller

Beutenmüller, Wm.: Notes on Black Mt. Beetles. Bull. Am. Mus. Nat. Hist., vol. 19, p. 515, 1903.

Electotype: ♂, American Museum of Natural History. Beutenmüller, collector.

Electo-allotype: ♀, American Museum of Natural History. Beutenmüller, collector.

Paratypes (cotypes): 7♂s, American Museum of Natural History; 3♂s, 1♀, U. S. National Museum. Beutenmüller, collector.

Type locality: "Mt. Mitchell, North Carolina (Pl. 65)."

Electotype ♂*:* L. 21.4 mm.; W. 8.4 mm.; h. ind. 0.43; p. ind. 0.81; e. ind. 0.72; a. ind. 0.43; t. ind. 0.75. Above, green-black; below, black, tarsi dark brown, elytral epipleurae purple-black (Pl. 67, fig. 6).

Electo-allotype ♀*:* L. 23.5 mm.; W. 9.2 mm.; p. ind. 0.85; e. ind. 0.74; a. ind. 0.47. Color as in type.

Paratypes: 4♂s: p. ind. 0.82–0.88; e. ind. 0.65–0.71; a. ind. 0.42–0.47; t. ind. 0.70–0.82. Green-black with faint violaceous reflections.

4♀s: p. ind. 0.80–0.83; e. ind. 0.67–0.71; a. ind. 0.43–0.47. Green-black often with faint violaceous reflections; occasionally violaceous black with greenish margins.

Aeneicollis is not a high altitude variety of *andrewsi* as Roeschke and others have treated it but it is a distinct species with very characteristic male genitalia (Pl. 71, figs. 1–5). It is easily distinguished by its dark coloration, by its very much constricted straight-sided, top-shaped pronotum, by its irregular elytral sculpture, interrupting the costae everywhere excepting on the central discal area, and by its reduced humeri. The elytral epipleurae are coarsely, rugosely punctured. The male front tarsi, however, resemble those of *andrewsi montana* (Pl. 69, fig. 14), though the first plantar pad is relatively short.

Chorology: The author has seen specimens only from the Black Mountains, a high range in central western North Carolina situated north of the French Broad River. The species is typical of the spruce forests near and on the summits (5000–6500 ft.) of the highest mountains. Its almost black coloration and irregularity of sculpture reflect this choice of habitat. The following records are represented by specimens seen and dissected by the author: "Mt. Mitchell," Buncombe and Yancey Cos.; "N. C. mountain summits" (type series); Black Mts., N. C. (more inclusive term for same region); High Hickory Mt., Swannanoa, Buncombe Co., N. C. (3000 ft.). Records from the Balsam Mts., Madison Co., N. C., have not been verified but probably refer to *tricarinata*, a related species.

Synonymy: The name *purpurata*, applied by Beutenmüller (1918) to more purplish specimens does not seem to the author to carry sufficient analytical value to justify even varietal recognition. More or less green or purple specimens occur together.

4. **S. tricarinata** Casey

Casey, T. L.: Mem. Coleop., vol. 5, p. 25, 1914.

Type: ♂, U. S. National Museum. Beutenmüller, collector.

Type locality: "Blue Ridge Mts., North Carolina."

Type ♂: L. 20.9 mm.; W. 8.0 mm.; h. ind. 0.42; p. ind. 0.83; e. ind. 0.70; a. ind. 0.44; t. ind. 0.64. Above, metallic green-black, pronotum slightly brighter; below, black, elytral epipleurae dark brown, tarsi dark brown (Pl. 67, fig. 5).

Casey described this form as a subspecies of *aeneicollis* which latter species he recognized. *Tricarinata* however, differs so drastically from *aeneicollis* in aedeagal equipment (see key) that there is little doubt of its inability to cross with *aeneicollis* should the ranges of the two overlap (Pl. 71, figs. 6–7). Externally, these species are very similar. *Tricarinata* is well named since its most diagnostic habitus character is the presence of three carinae on each side of the elytral suture which represent the modification of three homologous costae (the fourth, eighth and twelfth) slightly elevated in the humeral region of *aeneicollis*. In *tricarinata*, these costae extend as carinae to converge near the elytral apex of each elytron and to continue as one conspicuous ridge to the actual apex. The elytral punctures are even coarser and more irregular than in *aeneicollis* leaving intact a still smaller discal and anterolateral area of costae. Also the elytral epipleurae are still more coarsely punctate. The humeri, especially in the male, are more reduced. All these are characters of degree rather than kind. However, a conspicuous flattening of the pronotal disc which is transversely rugose, and a similar flattening especially evident in males, of the elytra between the humeri is typical and diagnostic of *tricarinata*. The male front tarsi resemble those of *aeneicollis* (Pl. 69, fig. 15).

A selection of specimens representing the extremes in size and color of a large series from near the probable type locality have the following characteristics: 4♂s: L. 19.8–22.8 mm.; W. 7.7–8.4 mm.; p. ind. 0.76–0.82; e. ind. 0.68–0.71; a. ind. 0.43–0.49; t. ind. 0.62–0.73. Green-black sometimes rather brilliant, often with slight violaceous reflections. 4♀s: L. 22.8–25.6 mm.; W. 8.9–9.6 mm.; p. ind. 0.77–0.84; e. ind. 0.65–0.71; a. ind. 0.44–0.51. Green-black often with slight violaceous reflections to the less usual violet-black with green-black disc.

Chorology: This is another high altitude species occurring, so far as the author's records show, only in the high Smoky Mountains along the North Carolina—Tennessee border from the Little Tennessee River on the south to the Big Pigeon River on the north. Restricted for the most part to its lofty habitat in the spruce forests, above 4500 ft., the species has had no opportunity, since acquiring this habitat, of crossing the river valleys and hybridizing with *aeneicollis* its nearest relative.

The two species, both mountain-top-bound, represent true isolation products.

Of the many mountain ranges to which "Blue Ridge Mts., N. C." might refer, the author has chosen the Smoky Mountains to represent the type locality until evidence appears that this species occurs in the more easterly ranges. One thing is certain—it has never been taken in the Black Mountains and therefore presumably does not occur north of the French Broad River. The Nantahala Range of the southern Blue Ridge, however, might contain it; the records of *aeneicollis* (Wenzel collection) from the "Balsam Mountains" probably refer to *tricarinata* or to one of its possible races.

The following authenticated records are before the author: Forney Creek, Swain Co., Smoky Mts., N. C., Bradley and Knorr; Newfound Gap, Smoky Mts., Swain Co., N. C., and Sevier Co., Tenn., Darlington; Mt. Guyot, Swain Co., Smoky Mts., N. C., Barksdale.

5. **S. guyoti** Leconte

Leconte, J. L.: Addit. to Coleop. Fauna of U. S. Proc. Phil. Acad., p. 363, 1866.

Type ♀ : Museum of Comparative Zoology.

Type locality: "Black Mountains, North Carolina" (Pl. 65).

Type ♀ : L. 31.2 mm.; W. 12.8 mm.; h. ind. 0.41; p. ind. 0.85; e. ind. 0.73; a. ind. (impossible to measure because of shrunken state of specimen due to immaturity). Head and pronotum green-black, elytra aeneous with slight violaceous reflections (the extreme bronzing is due to immaturity).

This is the largest and most variable (especially as to pronotal margins) species of *Steniridia*. It is easily distinguished from the others by its relatively large, convex elytra and by its front tarsi which, in the male, are very narrow and equipped with a much reduced pad on the first segment (Pl. 69, fig. 10). The aedeagus is very characteristic (see key); it serves to separate the species from the rest of *Steniridia* and is a much more constant character than external habitus (Pl. 72, figs. 1–3). The pronotal punctures completely encircle the disc and often are mingled with coarse, irregular, transverse rugosities. The humeri are as distinct as in *andrewsi montana*. The fifth, sixth, and seventh costae and ninth, tenth, and eleventh are merged, to a greater or lesser extent, by confluence and irregular striational punctation, over the apical two thirds of the elytra. As in *aeneicollis* and *tricarinata*,

the striae of the apical fourth of the elytra are completely obliterated by irregular punctures leaving only an embossed apical carina (the combined fourth and eighth costae).

The following are typical of *guyoti*:

Pennington Gap, Va.: ♀ : L. 29.5 mm.; W. 12.0 mm.; p. ind. 0.80; e. ind. 0.70; a. ind. 0.44. Violaceous-black with aeneous reflections.

Nantahala Mts., N. C.: ♂: L. 26.6 mm.; W. 10.8 mm.; p. ind. 0.75; e. ind. 0.71; a. ind. 0.44; t. ind. 0.24. Green-black, wide marginal area slightly violaceous (Pl. 68, fig. 1).

Mt. Sterling, N. C.: ♀ : L. 28 mm.; W. 11.7 mm.; p. ind. 0.85; e. ind. 0.74; a. ind. 0.50. Black with faint violaceous reflections.

Chorology: Like the preceding two species, *guyoti* is an inhabitant of the higher altitudes frequenting heavily wooded, mountain-side ravines (3500 ft. and above) and especially the moist, mountain-top spruce forests (4000–6000 ft.) where it occurs in company with *aeneicollis* or *tricarinata*. Its dark coloration and irregular sculpturing reflect the moist, cool, shady conditions under which it lives. Because of the tendency of the insect to keep close to the summits, it is expected that further study will disclose each mountain-top colony of *guyoti* to be a distinct race. No striking evidence of raciation has been found, probably due to lack of available material. *Guyoti* seems to be uniformly variable over its wide range which includes mountains on both sides of the French Broad River—a remarkable fact, as the valley of this stream acts as a very effective barrier to other flightless, monticolous species.

The exact localities of the specimens measured are recorded below: Pennington Gap, Lee Co., Va., Hubbard and Schwartz; Mt. Sterling, Haywood Co., N. C., 4000 ft., Barksdale; Highlands, Macon Co., N. C.

Synonymy: 5′. *S. guyoti* var. *angelli* Beutenmüller

Beutenmüller, Wm.: Notes on *Cychrus*. Brook. Ent. Soc., vol. 13, no. 4, p. 89, 1918.

Electotype: ♂: American Museum of Natural History. Beutenmüller, collector.

Type locality: "Mt. Mitchell, Black Mts., N. C."

Darlington (1931) described *confusus* as a distinct species closely related to *guyoti* but differing in the extreme narrowness of the pronotal margin. The type locality is Newfound Gap to Clingman's Dome, Smoky Mountains. As pointed out by Van Dyke, paratypes from the Black Mountains agree perfectly with cotypes of Beutenmüller's *angelli*. It is therefore necessary to suppress the name *confusus* and desig-

nate an electotype of *angelli* from the original cotype series. *Angelli* is not a species or a race—it is merely an ecological variant characterized by its longitudinal pronotum, its nearly black color and more extensive breaking up of elytral costae. The aedeagi of the two forms are identical (Pl. 72, figs. 1–3).

The variation which *guyoti* var. *angelli* exhibits is brought out in the following measurements of material selected for the purpose:

Black Mts., N. C.: 3♂s: L. 25–28 mm.; W. 9.9–11.1 mm.; p. ind. 0.88–0.95; e. ind. 0.70–0.73; a. ind. 0.42–0.48; t. ind. 0.28–0.32. Violaceous-black to black with very slight violaceous reflections, sometimes with a greenish sheen.

2♀s: L. 29.1–31.9 mm.; W. 12.3–13.3 mm.; p. ind. 0.83–0.89; e. ind. 0.73–0.75; a. ind. 0.46–0.50. Color as in males.

Roan Mt., N. C.: ♀: L. 28.8 mm.; W. 11.7 mm.; p. ind. 0.88; e. ind. 0.71; a. ind. 0.46. Green-black with faint violaceous reflections.

Smoky Mts., N. C.: ♂: L. 25.5 mm.; W. 10.0 mm.; p. ind. 0.90; e. ind. 0.71; a. ind. 0.47; t. ind. 0.26. Violaceous, nearly black (Pl. 68, fig. 2).

♀: L. 29.5 mm.; W. 12.7 mm.; p. ind. 0.87; e. ind. 0.76; a. ind. 0.47. Blue-green-black.

The following records refer to specimens studied: Mt. Mitchell, Black Mts., about 5000–6000 ft., Beutenmüller; Roan Mt., Mitchell Co., N. C.; Newfound Gap, Sevier Co., N. C., about 6000 ft., Darlington; Mt. Leconte, Sevier Co., Tenn., 5000 ft., Valentine.

Chorology: Beutenmüller considered *angelli* as a black phase of *guyoti*. Since the two definite localities (Highlands, N. C., Pennington Gap, Va.) from which broadly margined *guyoti* is known, are both in relatively low, rolling mountains, it is reasonable to suppose that the expanding margin of *guyoti* with the attendant heightening of surface refraction, is correlated with low altitude factors. Typical *guyoti* is far rarer than its narrow-necked high altitude phase, *angelli*, a fact which might be interpreted as the result of life under conditions which are not ideal. Intermediate altitudes (Mt. Sterling 4000 ft.) produce intergrades.

6. **S. lodingi** sp. n.

This species is perhaps the most distinctive in the entire group *Steniridia*. Its flatness, smoothness, and wide cordate appearance make it an easy form to recognize without the necessity of dissecting genitalia. However, a considerable range of variability may lead to misinterpretation if the characters described below are too strictly applied.

The types were collected by Dr. Henry P. Löding in honor of whom the author takes great pleasure in naming the species.

Chorology: Brilliancy of color and fineness of sculpture are, in this species, again correlated with a low altitude habitat. Rivers, not mountain ranges, were evidently followed in the distribution of *lodingi*, which possibly originated from a *ridingsi*-like ancestor on the highlands of northeastern Alabama and migrated down the Tennessee and down the tributaries of the Tombigbee and Alabama Rivers until the edges of the flood plains were reached.

6a. *S. lodingi* s. str.

Type: ♂, U. S. National Museum. H. P. Löding, collector.

Paratype: ♂, Collection of H. P. Löding.

Type locality: Monte Sano, Madison Co., Alabama (Pl. 65).

Type ♂: L. 21.8; W. 9.6 mm.; h. ind. 0.45; p. ind. 0.93; e. ind. 0.80; a. ind. 0.43; t. ind. 0.25. *Color:* above, deep rather brilliant violaceous, head and pronotum blacker, former and margins of latter as well as narrow margin of elytra with blue reflections; below, black; appendages reddish brown distally, dark brown proximally (basal four antennal segments and tibiae), femora black. The *pronotum* is cordate with very narrow, abruptly reflexed margins; anterior angles subacute, lateral angles almost obliterated, posterior angles rounded; anterior margin evenly arcuate, posterior margin slightly convex; distance from anterior angle to lateral seta 1.9 mm.; margins, basal prominences and anterior discal triangle of pronotum sparsely punctate. *Elytra* very wide with humeri much expanded giving the body a distinctly cordate appearance; disc very flat; margins relatively wide, strongly reflexed; elytral epipleurae very deep, rather evenly, profusely punctate; costae flat, uninterrupted except at extreme apical end (on disc, not further than 3.5 mm. from apex), the fourth and eighth combining to form a vague apical carina; striae evenly, rather shallowly punctate; margin with wide posterior fossae, each containing on its external wall an elongate, divided tubercle; apex produced. Front *tarsus* of male similar to that of *guyoti*, plantar pads much reduced. *Aedeagus* relatively small, with well developed transfer apparatus as described in key (Pl. 68, fig. 3; Pl. 69, fig. 11; Pl. 72, figs. 4–5).

Paratype ♂: L. 22.1 mm.; W. 9.0 mm.; h. ind. 0.43; p. ind. 0.95; e. ind. 0.74; a. ind. 0.38; t. ind. 0.33. Violaceous, elytra somewhat more brilliant than in type. Elytral disc flatter, humeri less pronounced than in type.

Additional specimens from Tuscaloosa, Alabama, are not included in the type series because of difference in locality. However, they are essentially identical with the types in all respects, including genitalia. Their measurements are as follows: ♂: L. 21.9 mm.; W. 6.75 mm; p. ind. 0.90; e. ind. 0.78; a. ind. 0.43; t. ind. 0.27. Dark violaceous with green reflections. ♀: L. 22.6 mm.; W. 9.7 mm.; p. ind. 0.93; e. ind. 0.78; a. ind. 0.46. Color exactly as in type.

Chorology: The type race of *lodingi* has been taken on both sides of the Tennessee River, the specimens from the south side coming from the valley of the Big Warrior River whose headwaters are close to the south bank of the Tennessee.

All the records available for the type race are these: Monte Sano, Madison Co., Alabama, H. P. Löding (type and paratype); Tuscaloosa, Tuscaloosa Co., Alabama, Archer, Löding and W. B. Jones.

6b. *S. lodingi obscura* subsp. n.

Type: ♂, U. S. National Museum. H. H. Smith, collector.
Allotype: ♀, U. S. National Museum. H. H. Smith, collector.
Paratypes: 2♂s, ♀, U. S. National Museum. H. H. Smith, collector.
Type locality: Wadley, Randolph Co., Alabama (Pl. 65).

Type ♂: L. 21.0 mm.; W. 8.7 mm.; h. ind. 0.48; p. ind. 0.88; e. ind. 0.73; a. ind. 0.45; t. ind. 0.27. Head and pronotum black, elytra blue-black with violaceous reflections (Pl. 68, fig. 4).

Allotype ♀: L. 23.7 mm.; W. 9.5 mm.; h. ind. 0.47; p. ind. 0.93; e. ind. 0.70; a. ind. 0.43. Blue-black.

Paratypes: 2♂s: L. 18.6–20.4 mm.; W. 7.8–8.2 mm.; p. ind. 0.87–0.95; e. ind. 0.73–0.74; a. ind. 0.45; t. ind. 0.21–0.36. Blue and violaceous-black.

♀: L. 19.5 mm.; W. 8.5 mm.; p. ind. 0.85; e. ind. 0.77; a. ind. 0.46. Head and pronotum blue-black, elytra violaceous-black.

This is a dark race of *lodingi* which further departs from the latter in being smaller, less compressed and more normally shaped throughout. The costae are less flat and wide, the elytral punctures more evident but the pronotum, which averages more transverse, is devoid of punctation. Tarsi and aedeagi are similar to those of type *lodingi*.

Chorology: Situated on the Tallapoosa River whose source is remote from the Tennessee, this colony shows indications of isolation. The dark coloration may be the result of life in low, very wet, shady situations such as are frequented by the black *Scaphinotus tenebricosus*.

7. S. ridingsi Bland

Ridingsi is the smallest and, phylogenetically, the most detached species in the series. The almost total absence of chitinized transfer apparatus in the aedeagus sets it apart from the other members of *Steniridia*. It is typical of piedmont *Steniridia* in exhibiting considerable metallic lustre and in having costae uninterrupted by irregular punctation. In habitus and in aedeagal equipment it suggests *lodingi*.

Chorology: Like the last species, *ridingsi* is evidently born of a mother stock inhabiting a high plateau country from which it migrated down the rivers whose sources lie within this mountainous, ancestral range. It is now found broken up into distinct races each occupying a river valley at relatively low altitudes. Thus the Potomac, Monongahela, and the James Rivers each support a subspecific colony some distance from their sources while the intervening Alleghenian divide represents the probable ancestral abode. A record from Tennessee (collected probably by H. A. Pilsbry) has not been investigated.

Ridingsi should be looked for in rocky, moist, shady, stream-side situations. Like all *Steniridia* it is most easily collected at night when it may occasionally be seen walking over the rocks. It is then readily attracted by the smell of black molasses; a little of this placed in a can sunk into the ground close to the largest boulders will almost certainly reward the collector should *Steniridia* be present at all. June, late September and early October seem to be the best times for taking *ridingsi*.

7a. *S. ridingsi* s. str.

Bland, J. H. B.: Proc. Ent. Soc. Phila., vol. 1, p. 354, 1863.

Type: ♀, Philadelphia Academy of Sciences.

Type locality: Hampshire Co., Virginia (Pl. 65).

The type race is the narrowest, smoothest and most brilliantly refractive of the three. Characteristics of the colony in Fairfax Co., Virginia, are taken from the following samples: 3♂s: L. 17.7–18.2 mm.; W. 6.7–6.9 mm.; h. ind. 0.46–0.47; p. ind. 0.87–0.94; e. ind. 0.69; a. ind. 0.41–0.43; t. ind. 0.64 (Pl. 68, fig. 5); 2♀s: 18.7–19.2 mm.; W. 6.9–7.0 mm.; h. ind. 0.45–0.46; p. ind. 0.92–0.94; e. ind. 0.63–0.66; a. ind. 0.41–0.43. Color of both sexes: above, head and pronotum dark violaceous-blue with blue-green reflections, elytra rather brilliant violaceous with strong aeneous reflections; below, black, tarsi rather light yellow-brown.

Chorology: This race inhabits the Potomac valley where it may be

collected in the moist stream-side forest at the foot of the steep river bank where it is very rocky. The following are localities of samples studied: Great Falls and Plummer's Island, Fairfax Co., Virginia.

7b. *S. ridingsi monongahelae* Leng

Leng, Chas. W.: A new variety of *Scaphinotus*. Jour. N. Y. Ent. Soc., vol. 25, no. 1, 1917.

Type: ♂, collection of Chas. Leng. T. N. Brown, collector.

Type locality: Uniontown, Fayette Co., Pennsylvania.

Topotypes: 3♂s: L. 15.9–17.8 mm.; W. 6.2–7.0 mm.; p. ind. 0.80–0.89; e. ind. 0.70–0.72; a ind. 0.42–0.45; t. ind. 0.55–0.63. Above, head blue-black, pronotum and elytra violaceous, often with green-blue reflections, pronotum darker (Pl. 68, fig. 6). 3♀s: L. 18.4–20.5 mm.; W. 7.2–8.2 mm.; p. ind. 0.87–0.89; e. ind. 0.70–0.71; a. ind. 0.42–0.44. Green-blue-black, elytra usually with violaceous reflections.

This is a distinct race differing from typical *ridingsi* in being broader throughout especially as to pronotal margins, in being flatter discally with impressed suture and in having more prominent humeri and coarser elytral punctures. It also tends to be darker in coloration.

Chorology: As Mr. Leng points out, this form inhabits the "Monongahela valleys west of the mountains." The author, however, has seen only topotype material from Uniontown.

Synonymy: Casey's (1920) *tenuiceps* which he described as a new species is a mere variant of *monongahelae*. The pronotum is slightly more elongate and the male front tarsi slightly narrower than usual. The aedeagi of the two forms are identical. As *tenuiceps* comes from Uniontown, the author has taken the liberty of including Casey's type male and the female paratype in his measured series of topotypes of *monongahelae*.

7c. *S. ridingsi intermedia* subsp. n.

Type: ♂, Museum of Comparative Zoology. Darlington, collector.

Type locality: Natural Bridge, Rockbridge Co., Virginia. (Pl. 65).

Type ♂: L. 15.6 mm.; W. 6.1 mm.; h. ind. 0.47; p. ind. 0.91; e. ind. 0.72; a. ind. 0.43; t. ind. 0.50. Above, head green-black, pronotum blue-green-black with violaceous reflections, elytra dark violaceous with blue-green reflections on margins; below, black, tarsi rather bright yellowish brown.

This specimen, the only one seen, agrees with typical *ridingsi* in having a relatively elongate pronotum with narrow margins. However, the sides are more rounded than in *ridingsi* from Fairfax Co. It agrees with race *monongahelae* in possessing relatively coarse elytral punctation and in the elytral disc which is flattened and depressed along the suture. The humeri, however, are more prominent than in the six topotypes of *monongahelae* before the author. The plantar pads of the first segment of the male's front tarsi are slightly less extensive than in either of the other two races. The aedeagus seems to be identical with *monongahelae*.

Chorology: This may be an isolated race living only in the valley of the James River.

CONCLUSIONS

1. The male genitalia (aedeagi), and probably also the female genital structures, afford a reliable key to an analysis of the forms of *Steniridia*, a group of highly variable species.

2. The original source of dispersed *Steniridia* colonies is probably the medium-high (above 2000 ft.) Allegheny plateau.

3. Speciation in *Steniridia* is clearly correlated with isolation. The latter may proceed as a result of either:

a. The ascent of high mountains to their summits where adjustments are made to special conditions and from which migration is impossible without encountering other, less congenial conditions lower down, or

b. The descent from the plateau into the river valleys where conditions are not vastly different from the ancestral environment but from which escape is impossible without the necessity of crossing dry hills and ridges.

4. The first process produces genitalically distinct species (*aeneicollis*, *tricarinata*); the second tends to evolve races or subspecies (forms of *andrewsi*, *ridingsi*, etc.).

5. Habitus characters and ecological conditions can be correlated in *Steniridia:* the blacker, greener forms more unstable as to contour and with irregular, vermiculate sculpture dwell in the highest cloud-forests; in contrast, stronger color refraction and finer, regular sculpture characterize populations inhabiting the valleys.

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EXPLANATION OF PLATES 65–73

PLATE 65

Localities of Steniridia

1. *Scaphinotus Steniridia ridingsi* Bland.
   a. *monongahelae* Leng. Type locality: Uniontown, Fayette Co., Pennsylvania.
   b. s. str. Type locality: Hampshire Co., Virginia; Great Falls, Fairfax Co., Virginia.
   c. *intermedia* subsp. n. Type locality: Natural Bridge, Rockbridge Co., Virginia.
2. *Scaphinotus Steniridia andrewsi* Harr.
   a. s. str. Neotype locality: Chapel Hill, Orange Co., North Carolina; type locality, "North Carolina."
   b. *germari* Chd. Type locality: Claiborne Co. (?), "Tennessee"; Pennington Gap, Lee Co., Virginia, and Pine Mountain, Harlan Co., Kentucky; Corbin, Whitley Co., Kentucky; Frankfort, Franklin Co., Kentucky; Cincinnati, Hamilton Co., Ohio; Gawley Mt., Fayette Co., West Virginia; Fairmont, Marion Co., West Virginia; Uniontown, Fayette Co., Penn.
   b′. *germari* Chd. Close to *andrewsi montana*. Mountain Lake, Giles Co., Virginia.

c. *montana* subsp. n. Type locality: Beech Mt., Avery Co., North Carolina; Grandfather Mountain, Avery Co., North Carolina.

c'. *montana* subsp. n. Close to *parvitarsalis* subsp. n. Mt. Guyot, Haywood Co., North Carolina.

d. *darlingtoni* subsp. n. Type locality: Newfound Gap, Sevier Co., Tennessee.

e. *parvitarsalis* subsp. n. Type locality: Clayton, Rabun Co., Georgia; Grimshawes, Jackson Co., North Carolina; Unaka Mts., Monroe Co., Tennessee.

f. *waldensia* subsp. n. Type locality: Sawyer's Springs, Hamilton Co., Tennessee.

3. *Scaphinotus Steniridia aeneicollis* Beut. Type locality: Mt. Mitchell (high altitude), Buncombe and Yancey Cos., North Carolina.

4. *Scaphinotus Steniridia tricarinata* Casey. Type locality: "Blue Ridge Mts., North Carolina," in all probability refers to Smoky Mts., North Carolina.

5. *Scaphinotus Steniridia violacea* Lec.

a. *carolinae* subsp. n. Type locality: "Blue Ridge Mts., N. C.," Transylvania Co. (?), North Carolina.

b. s. str. Type locality: "Mts. of Georgia," Towns and White Cos. (?), Georgia; Bryson City, Swain Co., North Carolina.

6. *Scaphinotus Steniridia guyoti* Lec. Type locality: "Black Mts.," Buncombe and Yancey Cos., North Carolina; Highlands, Macon Co., North Carolina; Smoky Mts., North Carolina—Tennessee; Pennington Gap, Lee Co., Virginia.

7. *Scaphinotus Steniridia lodingi* sp. n.

a. *obscura* subsp. n. Type locality: Wadley, Randolph Co., Alabama.

b. s. str. Type locality: Monte Sano, Madison Co., Alabama; Tuscaloosa, Tuscaloosa Co., Alabama.

PLATE 66

(3.3×)

Explanation: A. M. N. H.—American Museum of Natural History, New York City; J. M. V.—author's collection; M. C. Z.—Museum of Comparative Zoology, Cambridge, Mass.; P. A. S.—Philadelphia Academy of Sciences, Philadelphia, Pa.; U. S. N. M.—United States National Museum, Washington, D. C.

Fig. 1. *Scaphinotus Steniridia andrewsi montana* subsp. n. Type ♂. Beech Mt., Avery Co., North Carolina. U. S. N. M.

Fig. 2. *Scaphinotus Steniridia andrewsi* var. *amplicollis* Casey. Type ♂. Black Mts., Buncombe and Yancey Cos., North Carolina. U. S. N. M.

Fig. 3. *Scaphinotus Steniridia andrewsi parvitarsalis* subsp. n. Paratype ♂. Clayton, Rabun Co., Georgia. P. A. S.

Fig. 4. *Scaphinotus Steniridia andrewsi darlingtoni* subsp. n. Type ♂. Newfound Gap, Smoky Mts., Sevier Co., Tennessee. M. C. Z.

Fig. 5. *Scaphinotus Steniridia germari* Chd. close to *andrewsi* Harr. ♂. Mountain Lake, Giles Co., Virginia. M. C. Z.

Fig. 6. *Scaphinotus Steniridia andrewsi germari* Chd. ♂. Uniontown, Fayette Co., Pennsylvania. J. M. V.

PLATE 67

(3.3×)

For explanation see Plate 66.

Fig. 1. *Scaphinotus Steniridia andrewsi waldensia* subsp. n. Type ♂. Sawyer's Springs, Hamilton Co., Tennessee. P. A. S.
Fig. 2. *Scaphinotus Steniridia andrewsi* s. str. Neotopotype ♂. Chapel Hill, Orange Co., North Carolina. U. S. N. M.
Fig. 3. *Scaphinotus Steniridia violacea* Lec. Type ♂. "Mts. of Georgia." M. C. Z.
Fig. 4. *Scaphinotus Steniridia violacea carolinae* subsp. n. Type ♂. "Blue Ridge Mts., North Carolina." U. S. N. M.
Fig. 5. *Scaphinotus Steniridia tricarinata* Casey. Type ♂. "Blue Ridge Mts., North Carolina." U. S. N. M.
Fig. 6. *Scaphinotus Steniridia aeneicollis* Beut. Type ♂. Mt. Mitchell, Black Mts., Buncombe Co., North Carolina. A. M. N. H.

PLATE 68

(3.3×)

For explanation see Plate 66.

Fig. 1. *Scaphinotus Steniridia guyoti* Lec. ♂. Highlands, Macon Co., North Carolina. M. C. Z.
Fig. 2. *Scaphinotus Steniridia guyoti* var. *angelli* Beut. ♂. "Newfound Gap to Clingman's Dome, Smoky Mts., North Carolina, Tennessee." M. C. Z.
Fig. 3. *Scaphinotus Steniridia lodingi* sp. n. Type ♂. Monte Sano, Madison Co., Alabama. U. S. N. M.
Fig. 4. *Scaphinotus Steniridia lodingi obscura* subsp. n. Type ♂. Wadley, Randolph Co., Alabama. U. S. N. M.
Fig. 5. *Scaphinotus Steniridia ridingsi* Bland. ♂. Great Falls, Fairfax Co., Virginia. J. M. V.
Fig. 6. *Scaphinotus Steniridia ridingsi monongahelae* Leng. Topotype ♂. Uniontown, Fayette Co., Pennsylvania. J. M. V.

PLATE 69

Right front tarsi (fig. 9 left front tarsus) of male *Steniridia* (1.5×).

1. *Scaphinotus Steniridia andrewsi montana* subsp. n. Beech Mt., Avery Co., North Carolina.
2. *Scaphinotus Steniridia andrewsi germari* Chd. Ohio (southern).
3. *Scaphinotus Steniridia andrewsi* Harr. s. str. Neotopotype. Chapel Hill, Orange Co., North Carolina.
4. *Scaphinotus Steniridia andrewsi parvitarsalis* subsp. n. Unaka Mts., Monroe Co., Tennessee.
5. *Scaphinotus Steniridia andrewsi parvitarsalis* subsp. n. Paratype. Rabun Co., Georgia.
6. *Scaphinotus Steniridia andrewsi parvitarsalis* subsp. n. Grimshawes, Jackson Co., North Carolina.

7. *Scaphinotus Steniridia andrewsi montana* close to *parvitarsalis* subsp. n. Mt. Guyot, Swain Co., North Carolina.
8. *Scaphinotus Steniridia andrewsi darlingtoni* subsp. n. Paratype. Clingman's Dome, Swain Co., North Carolina.
9. *Scaphinotus Steniridia andrewsi waldensia* subsp. n. Type. Sawyer's Springs, Hamilton Co., Tennessee.
10. *Scaphinotus Steniridia guyoti* Lec. Highlands, Macon Co., North Carolina.
11. *Scaphinotus Steniridia lodingi* sp. n. Type. Monte Sano, Madison Co., Alabama.
12. *Scaphinotus Steniridia violacea* Lec. Type. "Mountains of Georgia."
13. *Scaphinotus Steniridia violacea carolinae* subsp. n. Paratype. "Blue Ridge Mts., North Carolina."
14. *Scaphinotus Steniridia aeneicollis* Beut. High Hickory Mt., Buncombe Co., North Carolina.
15. *Scaphinotus Steniridia tricarinata* Casey. Forney Creek, Swain Co., North Carolina.
16. *Scaphinotus Steniridia ridingsi* Bland. Great Falls, Fairfax Co., Virginia.

PLATE 70

Dissections of the vaginal cavities of three species of *Steniridia*, ventral aspect, with the ventral vaginal wall thrown to the left side.

Fig. 1. *Scaphinotus Steniridia andrewsi parvitarsalis*, subsp. n. Paratype. Mountain City, Rabun Co., Georgia. *a*—right style; *b*—right basal plate (coxite) with internal spicule; *c*—sternite (valvifer), probably ninth; *d*—ninth tergite; *e*—vaginal cavity, *e'* its external orifice (vulva); *f*—oviduct at the point of bifurcation, *f'* its orifice on the mid ventral line; *g*—annulus; *h*—chitinized plate; *i*—chitinized valvular spicule on posterior wall of common oviduct; *j*—gland?, *j'* its orifice; *k*—chitinized plate on dorsal wall of vaginal orifice.

Fig. 1a. Internal view of a portion of the ventral vaginal wall lettered as above.

Fig. 2. *Scaphinotus Steniridia violacea* Lec. Topotype. Tray Mt., Towns Co., Georgia.

Fig. 3. *Scaphinotus Steniridia tricarinata* Casey. Smoky Mts., North Carolina.

PLATE 71

Aedeagi of *Steniridia*, dorsal and right lateral views (10x) (as oriented in situ within the male) with details of the transfer apparatus (15×); in dorsal aspect (arcuate figures), the median lobe and one or both of its lateral appendages (parameres) are shown; in right lateral aspect (straight figures) the parameres have been omitted; in both views, the internal sclerotizations appear as dark masses showing through the walls of the median lobe.

Legend (for plates 71–73): *a*—transfer apparatus seen from the left (as though through concave wall of median lobe); *b*—cross section of same at zone indicated by a line on *a*; *c*—dorsal aspect of transfer apparatus; *d*—transfer apparatus seen from the right (as though through convex wall of median lobe).

Fig. 1. *Scaphinotus Steniridia aeneicollis* Beut. "Cotype." Mt. Mitchell, Black Mts., N. C. Left lateral aspect (ventral in copula position) in plane of diagonal line through fig. 3, showing the distended internal sac with its apical transfer apparatus and more proximal sclerotized folds.
Fig. 2. Enlarged detailed view of one of the paired, sclerotized folds partially opened.
Fig. 3. Dorsal aspect of the same aedeagus showing both parameres.
Fig. 4. *Scaphinotus Steniridia aeneicollis* Beut. High Hickory Mt., Buncombe Co., North Carolina.
Fig. 5. *Scaphinotus Steniridia aeneicollis* Beut. Same specimen.
Fig. 6. *Scaphinotus Steniridia tricarinata* Casey. Forney Creek, Swain Co., North Carolina.
Fig. 7. *Scaphinotus Steniridia tricarinata* Casey. Same specimen.
Fig. 8. *Scaphinotus Steniridia violacea* Lec. Type. "Mts. of Georgia."
Fig. 9. *Scaphinotus Steniridia violacea carolinae* subsp. n. Paratype. "Blue Ridge Mts., North Carolina."
Fig. 10. *Scaphinotus Steniridia violacea carolinae* subsp. n. Same specimen.

PLATE 72

Aedeagi of *Steniridia* (continued); for explanation see legend of Plate 71.

Fig. 1. *Scaphinotus Steniridia guyoti* var. *angelli* Beut. Clingman's Dome, Smoky Mts., North Carolina–Tennessee.
Fig. 2. *Scaphinotus Steniridia guyoti* var. *angelli*. Same specimen.
Fig. 3. *Scaphinotus Steniridia guyoti* Lec. Highlands, Jackson Co., North Carolina.
Fig. 4. *Scaphinotus Steniridia lodingi* sp. n. Type. Monte Sano, Madison Co., Alabama. Transfer apparatus from specimen from Tuscaloosa, Alabama.
Fig. 5. *Scaphinotus Steniridia lodingi* sp. n. Same specimen (type).
Fig. 6. *Scaphinotus Steniridia ridingsi* Bland. Great Falls, Fairfax Co., Virginia.
Fig. 7. *Scaphinotus Steniridia ridingsi* Bland. Same specimen.
Fig. 8. *Scaphinotus Steniridia ridingsi monongahelae* Leng. Topotype. Uniontown, Pennsylvania.
Fig. 9. *Scaphinotus Steniridia andrewsi montana* subsp. n. Type. Beech Mt., Avery Co., North Carolina.

PLATE 73

Aedeagi of *Steniridia* (continued); for explanation see legend of plate 71.

Fig. 1. *Scaphinotus Steniridia andrewsi* var. *amplicollis* Casey. Type. "Black Mts., North Carolina."
Fig. 2. *Scaphinotus Steniridia andrewsi germari* Chd. Uniontown, Fayette Co., Pennsylvania.
Fig. 3. *Scaphinotus Steniridia andrewsi germari* Chd. Hamilton Co., Ohio.
Fig. 4. *Scaphinotus Steniridia andrewsi montana* close to *germari* Chd. Mountain Lake, Giles Co., Virginia.
Fig. 5. *Scaphinotus Steniridia andrewsi germari* Chd. close to typical *andrewsi montana* subsp. n. Mountain Lake, Giles Co., Virginia.

Fig. 6. *Scaphinotus Steniridia andrewsi* s. str. Neotopotype. Chapel Hill, Orange Co., North Carolina.

Fig. 7. *Scaphinotus Steniridia andrewsi* s. str. Neotopotype. Same specimen.

Fig. 8. *Scaphinotus Steniridia andrewsi parvitarsalis* subsp. n. Paratype. Clayton, Rabun Co., Georgia.

Fig. 9. *Scaphinotus Steniridia andrewsi parvitarsalis* subsp. n. Unaka Mts., Monroe Co., Tennessee.

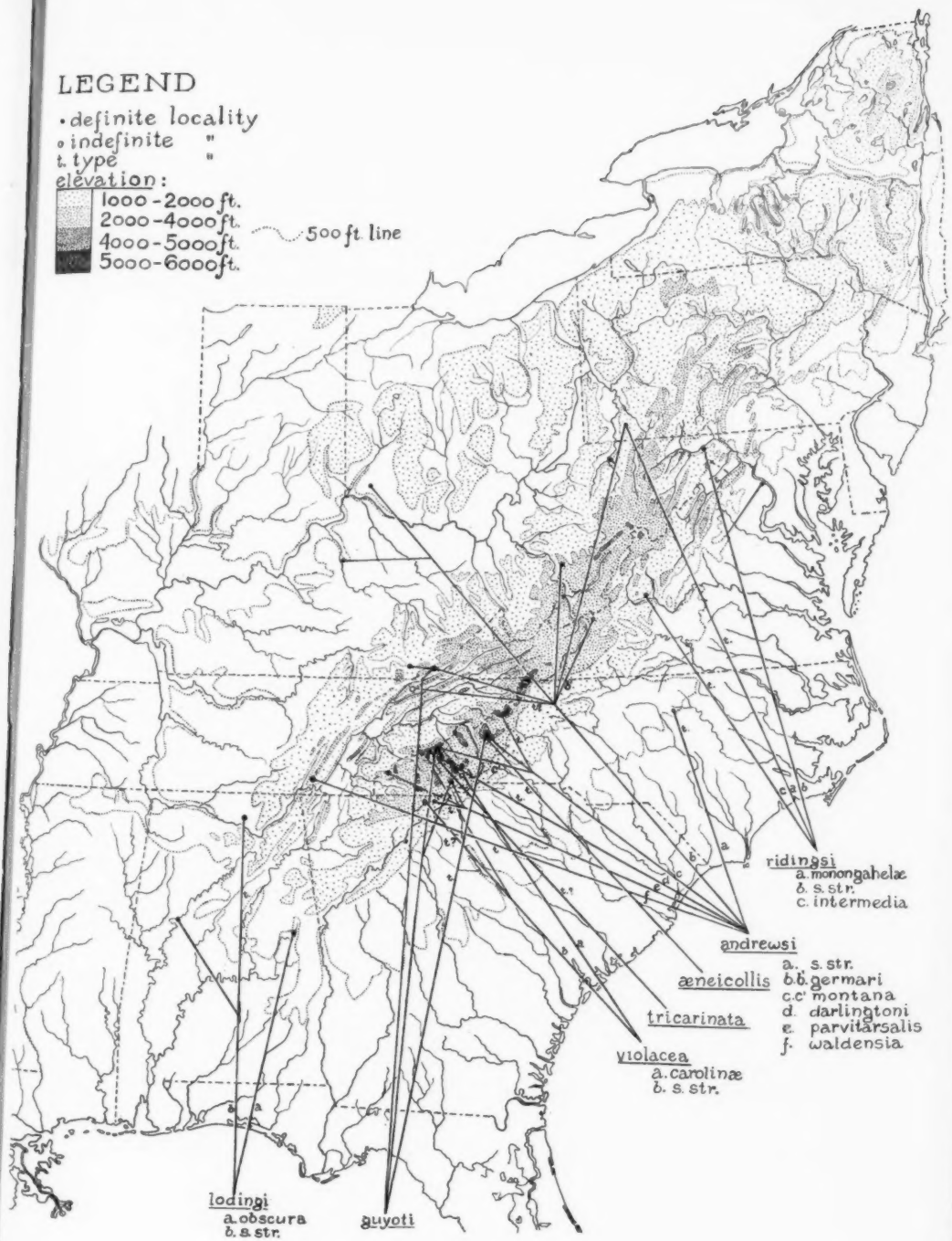

LEGEND
• definite locality
◦ indefinite "
t. type "
elevation:
1000-2000 ft.
2000-4000 ft.
4000-5000 ft.
5000-6000 ft.
500 ft. line
ridingsi
a. monongahelæ
b. s. str.
c. intermedia
andrewsi
æneicollis
a. s. str.
b b. germari
c c' montana
d. darlingtoni
e. parvitarsalis
f. waldensia
tricarinata
violacea
a. carolinæ
b. s. str.
lodingi
a. obscura
b. s. str.
guyoti

PLATE 66

PLATE 67

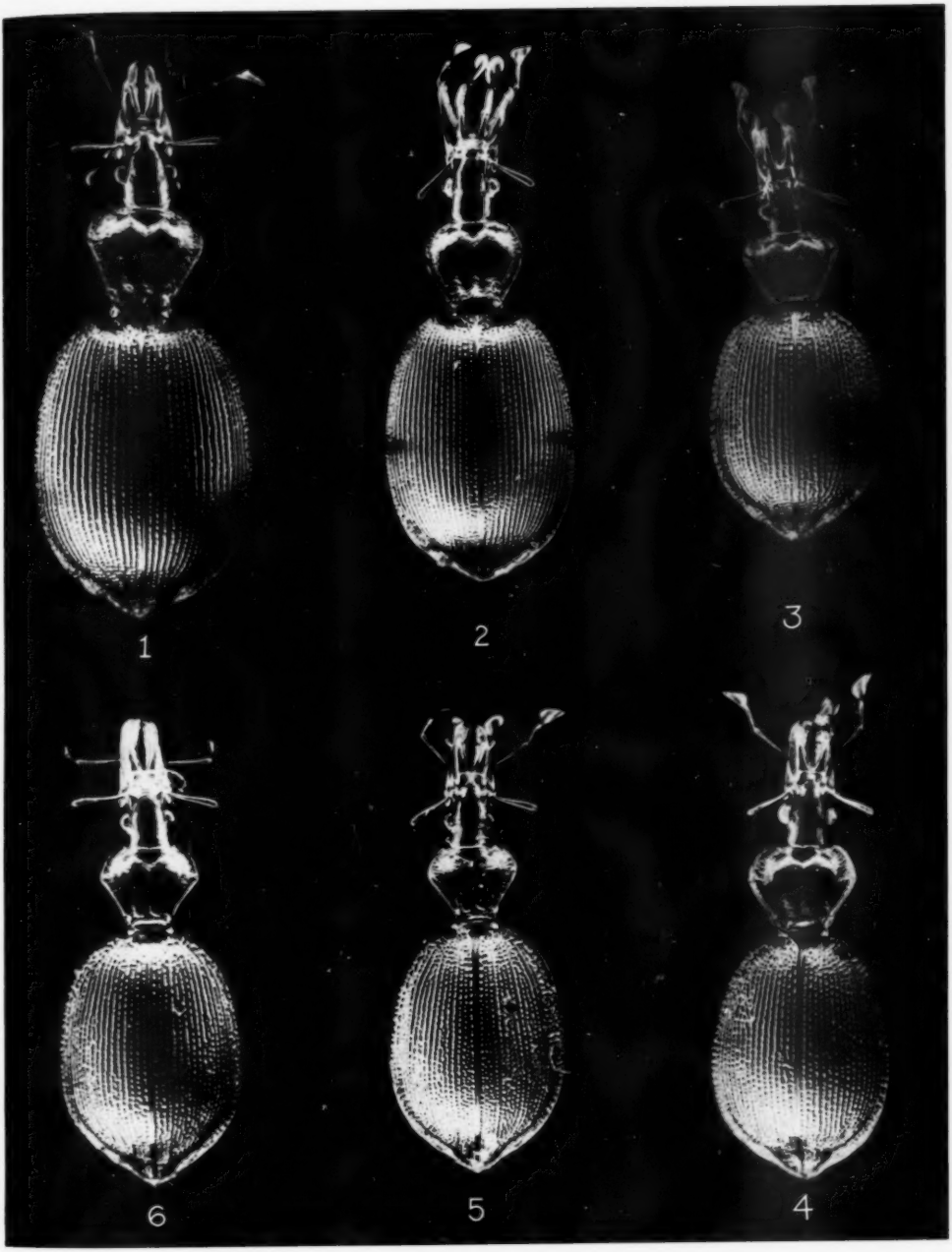
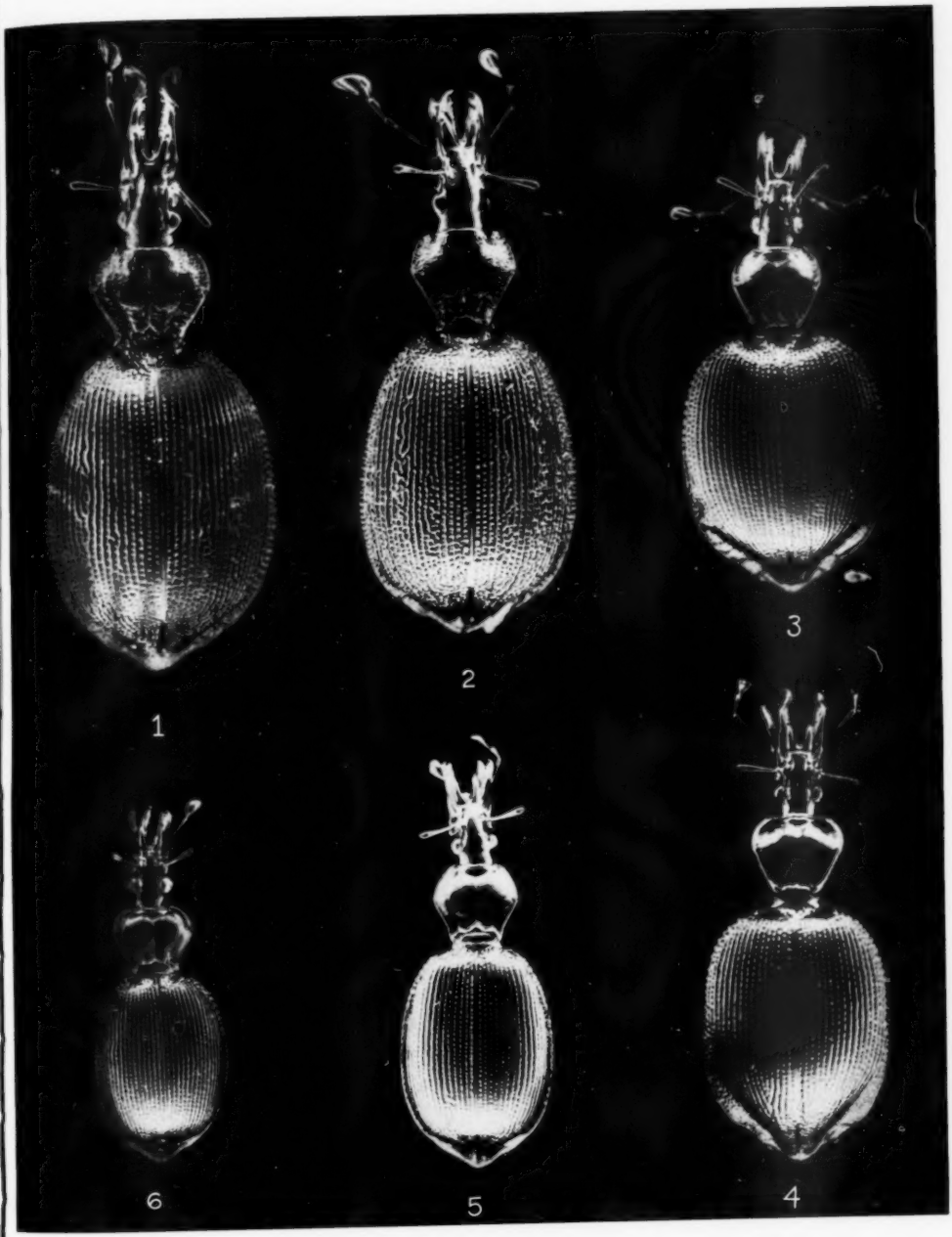


PLATE 68



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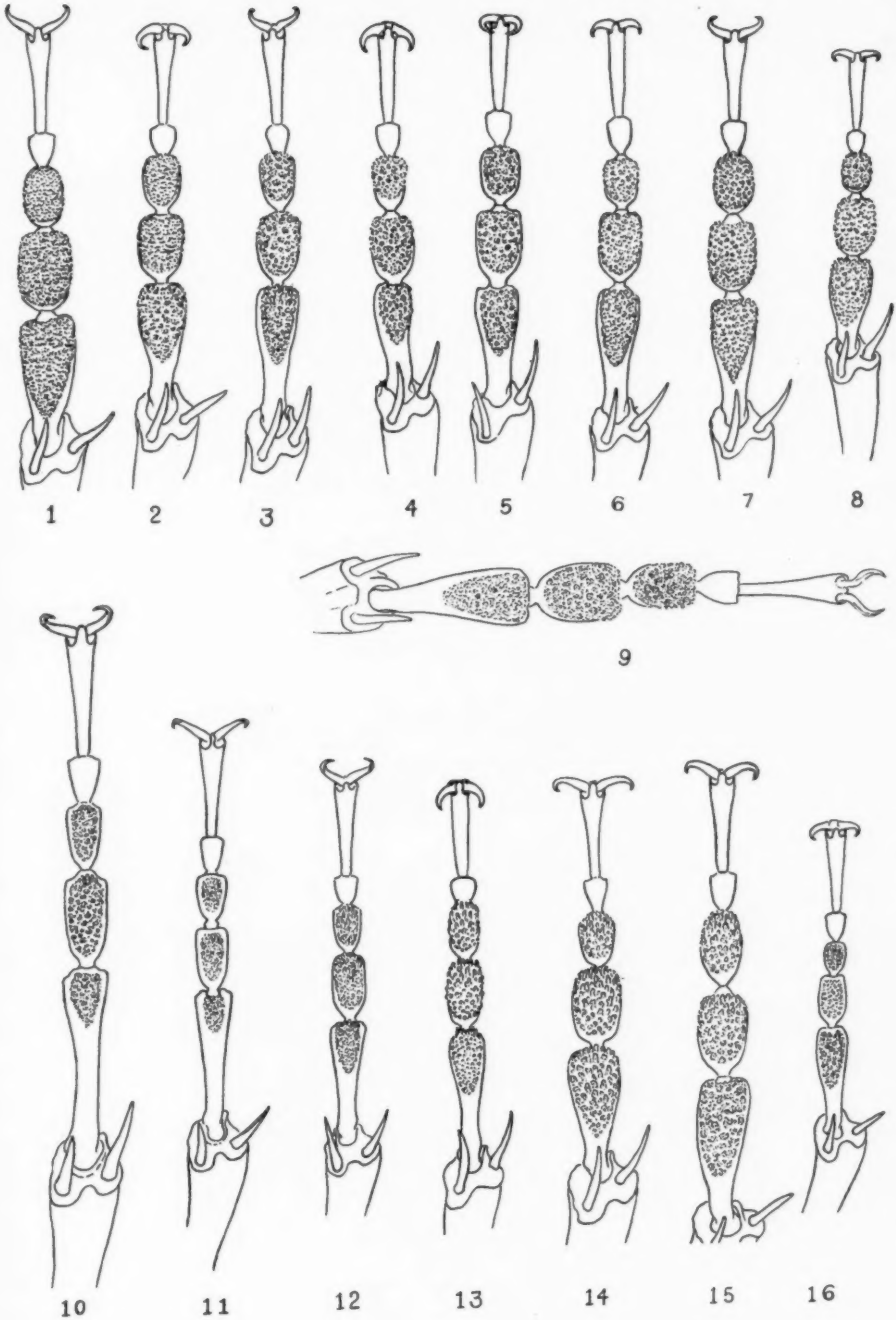


PLATE 70

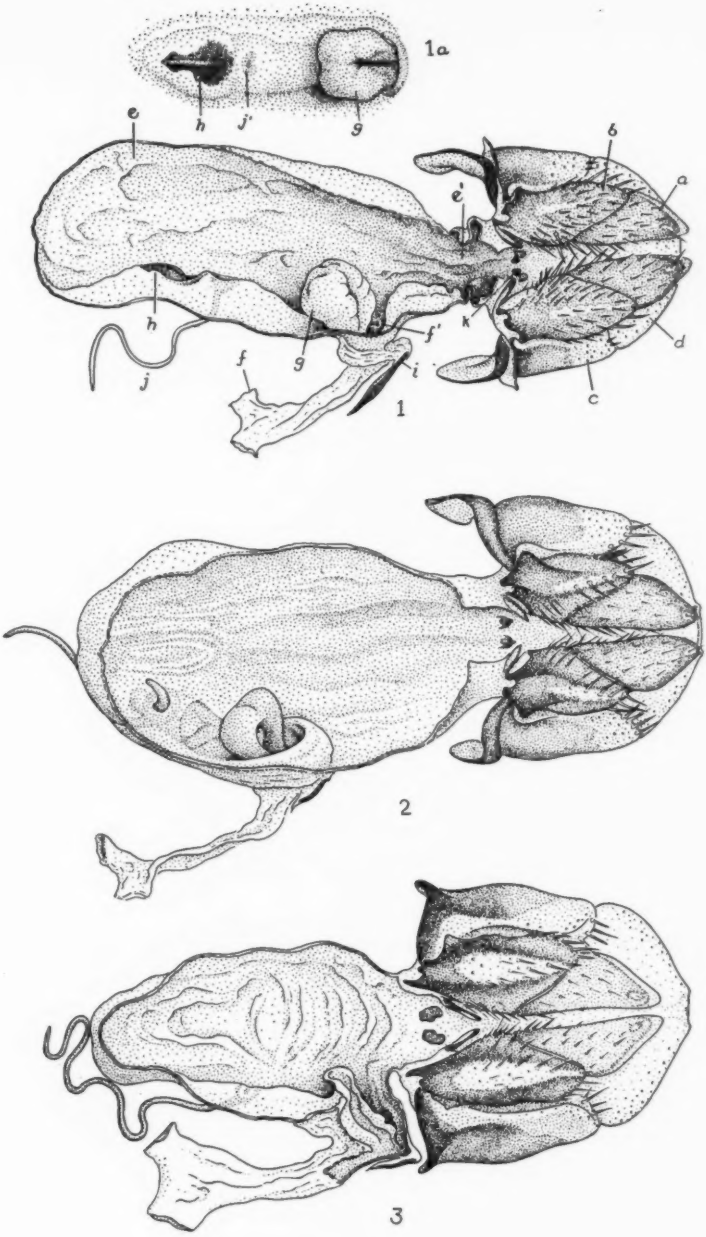


PLATE 71

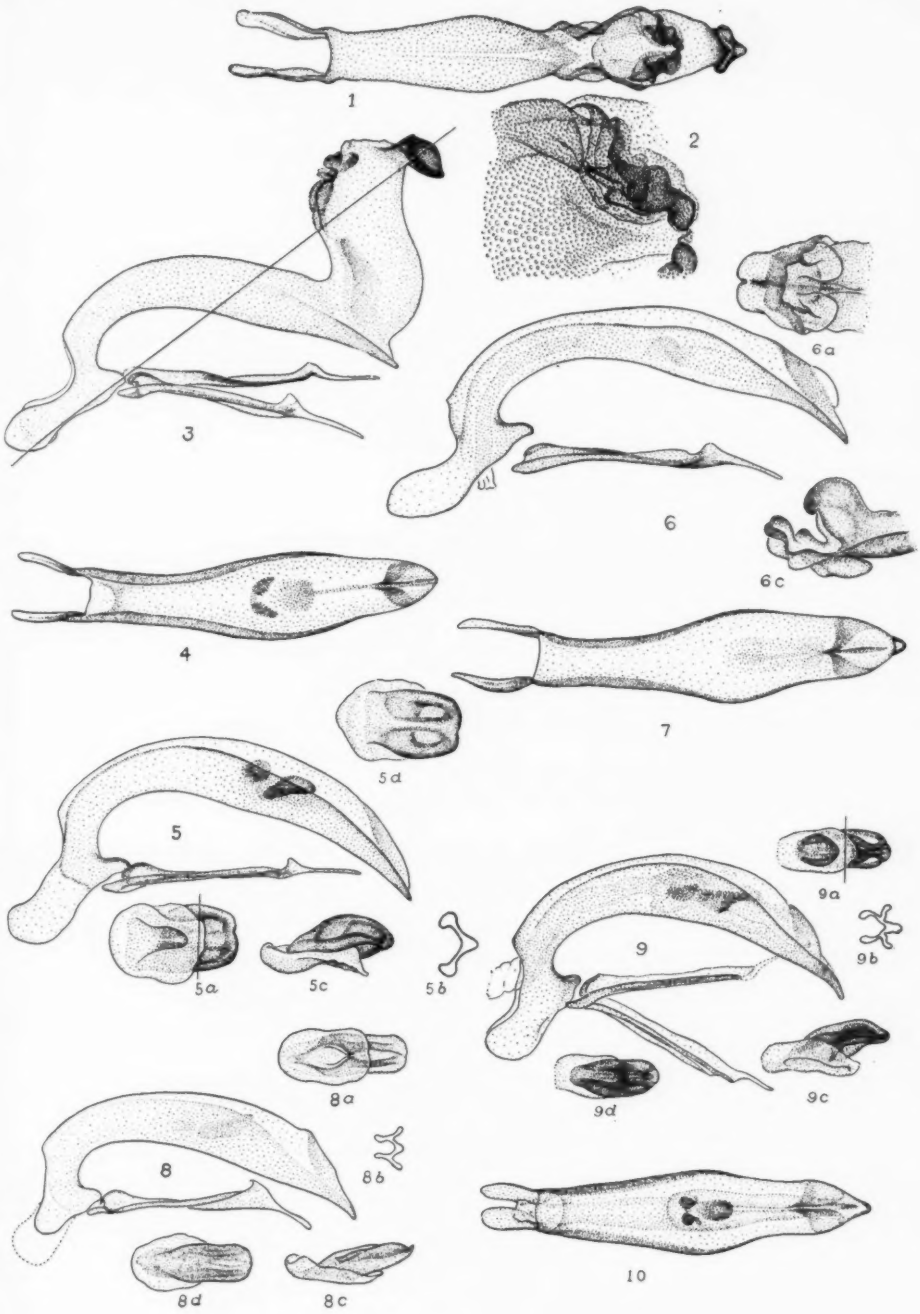
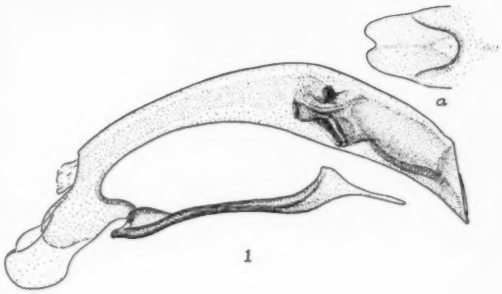


PLATE 72



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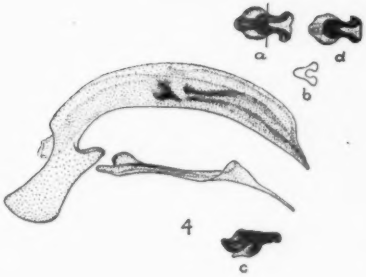

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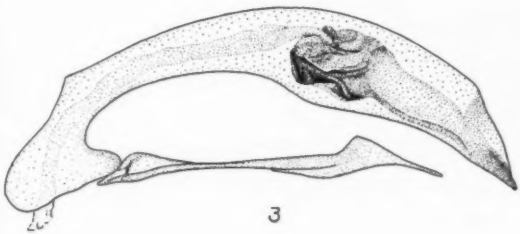

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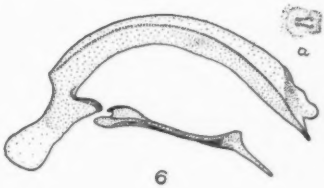

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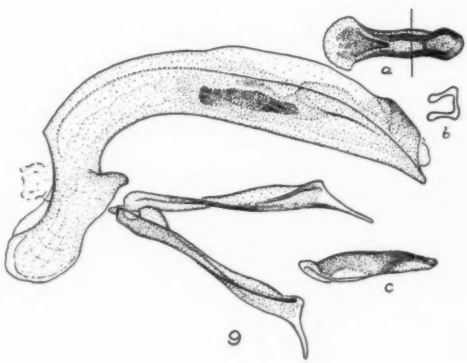

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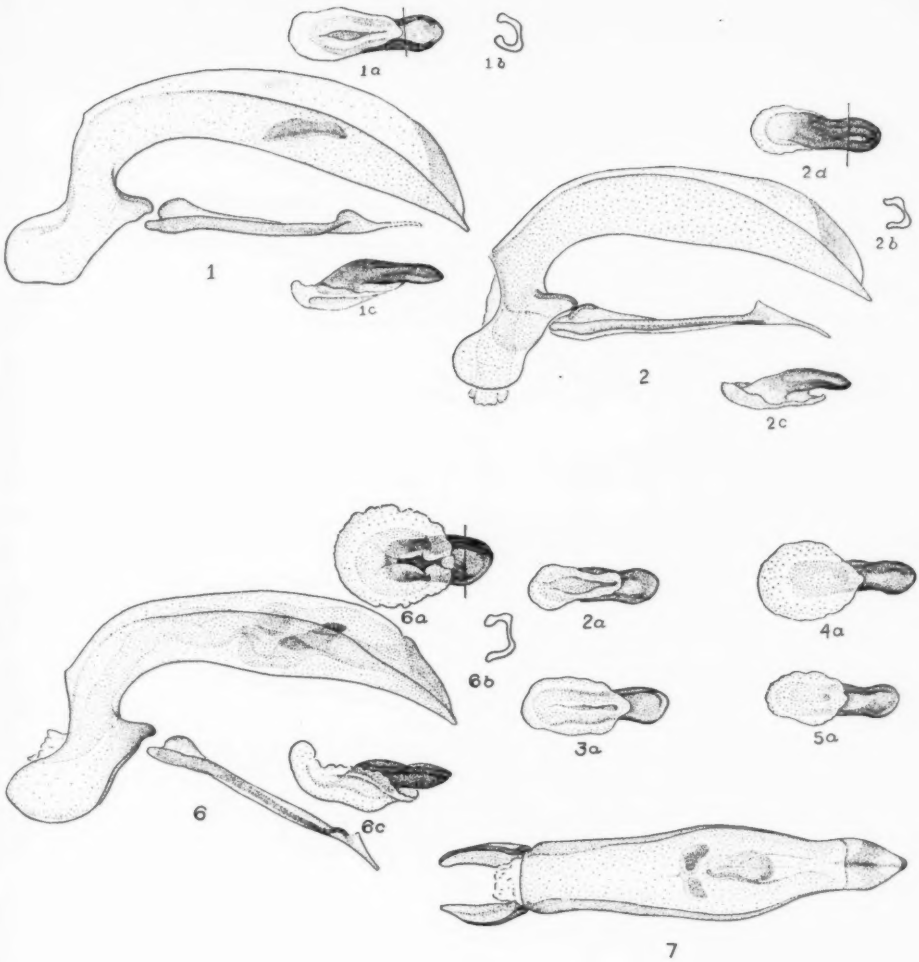
PLATE 73